PETROLEUM DEVELOPMENT AND TECHNOLOGY

1945

PETROLEUM DIVISION

A. I. M. E.

TRANSACTIONS

OF THE

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

(INCORPORATED) and Petroleum

Volume 160

PETROLEUM DEVELOPMENT AND TECHNOLOGY 1945

PETROLEUM DIVISION

PAPERS AND DISCUSSIONS PRESENTED BEFORE THE DIVISION AT MEETINGS HELD AT LOS ANGELES, OCT. 21–22, 1943, AND OCT. 19–20, 1944; HOUSTON, MAY 8–10, 1944; NEW YORK, FEB. 20–24, 1944 AND SCHEDULED FOR NEW YORK, FEB. 19–22, 1945 (MEETING CANCELED); ALSO THE PETROLEUM STATISTICAL REPORTS COVERING THE YEAR 1944.

PUBLISHED BY THE INSTITUTE
AT THE OFFICE OF THE SECRETARY
29 WEST 39TH STREET
NEW YORK 18, N. Y.

PRINTED IN THE UNITED STATES OF AMERICA

THE MAPLE PRESS COMPANY, YORK, PA.

FOREWORD

The year 1944 has been one of the most important in the history of the Petroleum Division, both from the standpoint of the role played by the individual members in contributing toward supply of a critical war material and collectively as a professional group in disseminating information with the objective of increasing the efficiency of the industry during extremely trying times.

The past year has also been a critical one as regards the activities of the Petroleum Division. The inadequacy of the Division in meeting the professional requirements of its members, particularly those of the petroleum engineer, have been becoming increasingly apparent and were brought to a head by events during the year. Under date of December 1, 1944, the chairman for 1944, Mr. W. S. Morris, addressed a letter to the members of the Petroleum Division with respect to the requirements of the Division as a group within the Institute. More than 900 replies were received, which contained many suggestions for improving the effectiveness of the Petroleum Division. Specific proposals were discussed with the Institute Board of Directors in February 1945 and are being given further study by an Institute Committee on Divisional Relationships.

For some time the question of eliminating the Production Statistics from the annual TRANSACTIONS volume has been under discussion. As a result of action taken by the General Committee, this question was referred by letter ballot to the membership of the Division under date of December 1, 1944. The results of the ballot showed 210 or 26 per cent of the replies in favor of elimination and 589 or 74 per cent voted for retention of the production statistics, and accordingly they will be continued.

The 1944 annual meeting was held in New York in February in accordance with past practice. A spring meeting of the Division was held in Houston in May in conjunction with a Regional Meeting of the Institute and the usual fall meeting was held in Los Angeles in October. These meetings were all well attended and the Division is grateful to the men who prepared and presented papers and to the officers and committeemen who contributed to the success of these meetings. The Papers and Programs Committee is to be especially commended for the excellent job it has done during the past year under difficult circumstances. The 1945 annual meeting was cancelled because of the war and the Division decided to discontinue the procedure of the past two years of holding a spring meeting. Definite plans for a fall meeting have not yet been made.

M. L. HAIDER, *Chairman*,
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NEW YORK, N. Y.
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THE ANTHONY F. LUCAS FUND AND MEDAL

In 1936 the Institute established the Anthony F. Lucas Gold Medal, to be awarded from time to time "for distinguished achievement in improving the technique and practice of finding and producing petroleum." These awards are sponsored by the Petroleum Division.

Captain Lucas was a pioneer in the oil industry, one of the early wildcatters and a leading mining and petroleum engineer. He was famous as the discoverer of Spindletop. He became a member of the Institute in 1895 and in 1913 was the first Chairman of the Petroleum and Gas Committee of the Institute, the forerunner of the present Petroleum Division. He also headed the Committee in 1914, 1917 and 1918.

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To J. Edgar Pew, February 1937
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E. DeGolyer, February 1940
Conrad (posthumously) and Marcel Schlumberger, February 1941
John Robert Suman, February 1943
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Chapter I. Production Engineering and Research

Applications of the Electric Pilot to Well Completions, Acidizing, and Production Problems in the Permian Basin

By P. J. Lehnhard* and C. J. Cecil*

(Houston Meeting, May 1944)

Abstract

The paper describes the use of the Electric Pilot in the Permian Basin for making permeability surveys of wells and for the selective acidization of wells. A general summary of the information obtained from the many permeability surveys run in this area is given, and the possible application of this information to reservoir control problems is discussed. The application of the Electric Pilot on specific wells, involving well completion, acidizing and workover operations is also included.

Introduction

The Electric Pilot is a comparatively new tool in oil-producing areas. From the beginning, the possibilities of this new service caught the imagination of many of the oil operators and acidizing engineers. Through the continued and ever increasing use of the pilot during the past year, and the close cooperation of the oil operators who have used this service, the efficiency and utility of the Electric Pilot service has been increased to a point where it is now a well established and recognized service.

There are two major uses for the Electric Pilot: (1) permeability survey; (2) selective acid treatments.

Permeability surveys are made to determine the thickness of the various permeable sections at the borehole, the vertical position of these zones at the bore hole, and the relative capacities of the various zones.

Nomenclature

Data obtained from the permeability survey are used to calculate three different indexes that pertain to the volume of fluid injected into the various permeable zones. A nomenclature for these various indexes has been set up, which correspond with the various productivity indexes, except that they are a measure of injected fluid rather than produced fluid. The nomenclature and definition of the indexes used in connection with a permeability survey by the Electric Pilot are as follows:

1. Capacity.—The volume of water injected into an individual permeable zone, in gallons per minute.

2. Capacity Index.—The volume of water injected into an individual permeable zone, in gallons per minute per pound per square inch differential pressure.

3. Specific Capacity Index.—The volume of water injected into an individual permeable zone in gallons per minute per pound per square inch differential per foot of thickness of the zone at the borehole.

Capacity is the most generally used index, and for planning initial acidizing procedures and most workover jobs it is sufficient. For comparing permeability surveys on the same well before and after

Manuscript received at the office of the Institute May 9, 1944, revised July 10, 1944. Issued as T.P. 1759 in Petroleum Technology, September 1944.

* Dowell Incorporated, Midland, Texas.

acid treatment or before and after a workover job, the capacity index must be used, as for comparative purposes the injection rates into the various zones must be corrected for the differential pressure applied. A detailed description of the apparatus and method involved has been given by Hefley and Fitzgerald.*

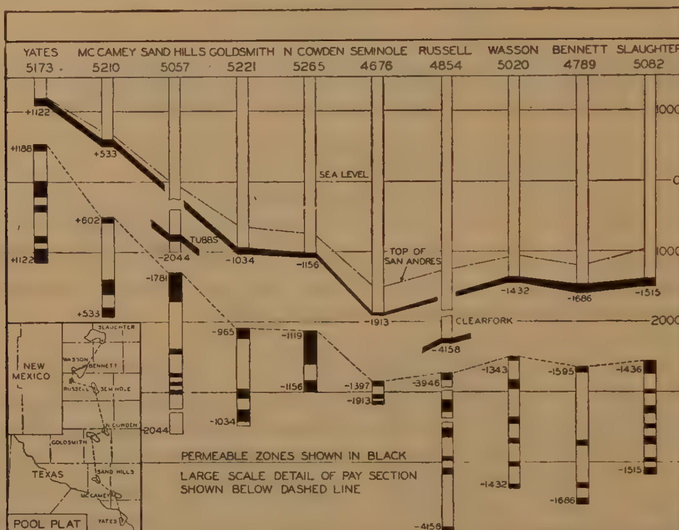

FIG. 1.—DISTRIBUTION OF PERMEABLE ZONES THROUGHOUT PAY HORIZON OF TYPICAL PERMIAN BASIN WELLS AS DETERMINED BY THE ELECTRIC PILOT.

The specific capacity index, which is a direct measure of the actual effective permeability of each permeable zone, appears to be and should be valuable in locating undesirable water or gas zones in a well, particularly in intermediate zones producing these fluids. Where a well is producing from a series of breaks, or permeable zones, which are all connected to a common water or gas reservoir, it is reasonable to assume that the most permeable zones will be depleted of oil most rapidly and that water or gas encroachment will begin through these zones.

In selective acidizing, the Electric Pilot is used to control the injection of acid into specific parts of the pay section; and it not only affords a method of control but also indicates, during the acid treatment, whether or not the acid is being injected into the desired section. A detailed description of the apparatus and method involved has been given by Hefley and Fitzgerald.*

PERMEABILITY SURVEYS

The permeability surveys run during the past year have been rather well distributed throughout the Permian Basin, so that representative surveys for nearly any geographic or geologic section have been obtained. These surveys indicate that, with very few exceptions, the fluid production of wells producing from limestone reservoirs enters the borehole through a series of two or more "breaks" or permeable zones of varying permeability. Fig. 1 shows the distribution of permeable zones throughout the pay horizon in typical wells in the Permian Basin. In the cross section at the top of the figure and the plat at the bottom are shown the structural and geographic locations of the wells; and immediately below each well on the cross section is shown an enlarged section of the

* D. G. Hefley and P. E. Fitzgerald: Selective Acidizing and Permeability Determination by an Electrical Method. *Trans.* A.I.M.E., (1944) 155, 223.

pay horizon with the permeable zones, as located by the pilot, in black. There is no attempt to correlate between these zones. The illustration is merely intended to and very little, if any, vertical communication between the various permeable sections. Data from selective acidizing work and permeability surveys appear to

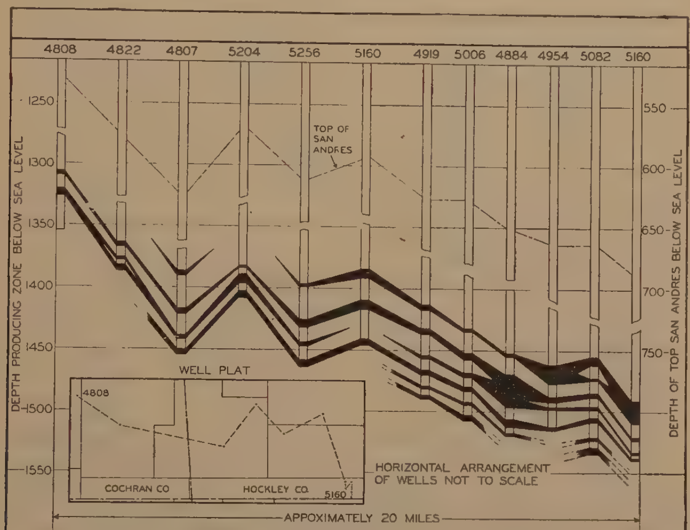

Fig. 2.—Cross section of Slaughter field, showing distribution and correlation of permeable zones as determined by the Electric Pilot.

show the banded nature of the permeable zones in typical Permian Basin wells.

In most wells the total vertical extent or thickness of the permeable zones at the borehole is much less than the total thickness of saturated section as determined by sample analysis. This difference raises the question of whether or not the total thickness of saturated section in the reservoir is efficiently drained through the comparatively thin openings or permeable zones at the borehole; particularly where such permeable zones are some distance apart vertically. It also raises the question of whether or not these permeable zones can be correlated between wells and whether the limestone reservoirs really consist of one large system with horizontal and vertical communication throughout, or whether the reservoir consists of a series of lenses, similar to a sand section between continuous shale breaks, which have horizontal communication between wells support the idea that the production in most limestone reservoirs is from a series of permeable zones that have horizontal communication between wells, and possibly over entire fields, with very little vertical communication.

Fig. 2 shows a cross section across the Slaughter field, with the permeable zones in each well as located by the Electric Pilot. The six wells on the right-hand side of the section are offset wells on the same lease. The close correlation of the permeable zones between the six wells and the dip of these zones from well to well as compared with the top of the San Andres lime suggest that such a banded condition might also exist over the entire field.

The Electric Pilot permeability survey is used only to determine the position of the permeable zones in the well, the thickness of these zones at the borehole, and the relative capacities of the various zones. It is not used for the determination of

saturation, porosity, or fluid content of the permeable zones directly; although when used in connection with other well information it will at times assist in ship. By the Electric Pilot, capacity is a measure of the actual effective permeability of the producing zones to water, while permeability by core analysis is a measure

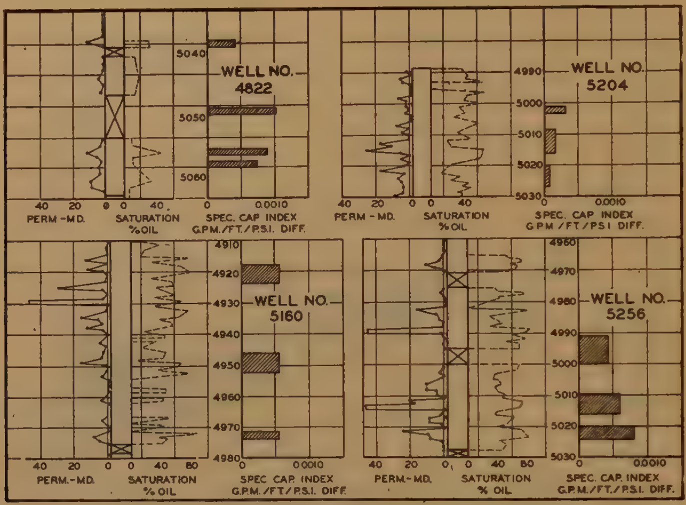

FIG. 3.—COMPARISON OF PERMEABILITY BY CORE ANALYSIS WITH SPECIFIC CAPACITY INDEX BY ELECTRIC PILOT ON FOUR WELLS IN SLAUGHTER FIELD.

determining the fluid content of such zones. The Electric Pilot, in its role of locating and evaluating zones with respect to permeability, appears to be more reliable and accurate than any other method in use at the present time. Fig. 3 shows a comparison of permeability by core analysis with capacity by the Electric Pilot on four wells in the Slaughter field. The majority of the permeable zones as picked out by the Electric Pilot and core log compare favorably; although the actual numerical values of capacity by the pilot show no direct relationship to the average permeability values of the zones in millidarcys. Because of the various and unknown factors —such as connate water content, dissolved gas, free gas—which are not reflected in laboratory measurements of permeability, and the fact that the samples measured in the laboratory represent only a very small portion of the entire drainage area; it is not surprising that these two methods fail to show any direct numerical relationship. of the permeability of core samples to a homogeneous fluid.

Fig. 4 shows a comparison of the drilling-time log and permeability survey on four typical Permian Basin wells. A few of the permeable zones as picked up by the drilling-time log and permeability survey agree but in the majority of cases there is no correlation between the two.

The Electric Pilot permeability survey cannot replace or detract from the values of well-logging methods that show saturation or fluid content throughout the producing horizon. In acidizing work particularly, saturation and fluid-content logs should be used along with the permeability survey in planning an acidizing program. The permeability survey, as it is now applied, has an accuracy of only about 3 to 5 per cent, so that permeable zones in a producing horizon that contain less than this percentage of the total capacity of the well may not be picked up. However, this does not mean that these zones will

not produce oil if they are properly acidized. A number of cases have occurred where zones that were shown as impermeable by the pilot, because of mudding or low percentage of natural capacity, have shown good saturation on the sample log; and selective acidization of these zones has led to greatly increased well production. Also, where such increases have occurred, when the well was surveyed with the Electric Pilot afterward the survey has shown this permeable zone, which was opened up with acid.

Pilot surveys for determining permeable zones can be of material assistance to the oil operator in working out the problems of reservoir control throughout the life of the field, and in the control of individual wells during their entire life; in well completion, acidizing, and workovers.

In any field, with either natural or artificial drive, where the operators attempt to produce the field as a unit or exercise any degree of reservoir control, it is obviously necessary to know as much as possible about reservoir conditions, and particularly the mechanics of the drainage or the movement of the fluids through the reservoir to the wells. The knowledge of the exact position, thickness, and capacities of the various permeable zones would appear to be the most valuable information obtainable concerning the mechanics of the drainage of the reservoir. If, in a limestone reservoir, the production is from a series of lenses with horizontal but little if any vertical communication, such as is shown as a possibility in Fig. 2, rather than from one large reservoir with vertical communication throughout, the most efficient method of producing the reservoir obviously would be to deplete all lenses at such a uniform rate that water or gas would not encroach into any well prematurely from any one of the many lenses.

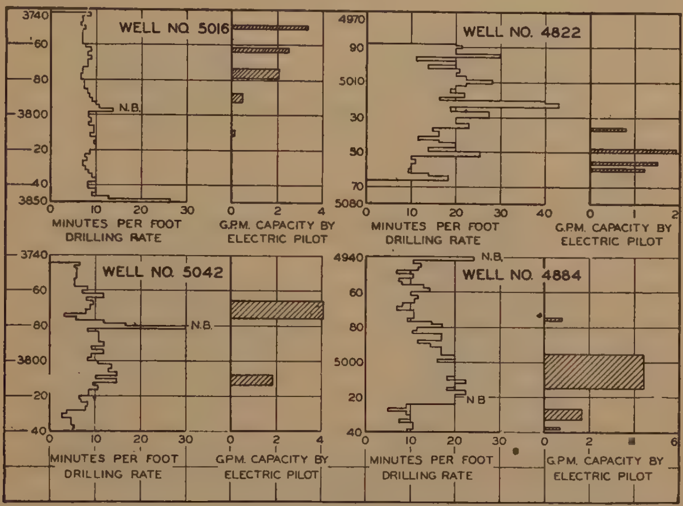

FIG. 4.—COMPARISON OF DRILLING-TIME LOG WITH CAPACITY BY ELECTRIC PILOT ON FOUR TYPICAL PERMIAN BASIN WELLS.

The knowledge of the exact position, thickness, and capacity of the permeable zones in each well, as it is drilled during the drilling and development program of a lease or field, is very important. When correlated with other information such as structural position, location of gas-oil and water-oil contacts, and saturation or fluid-content logs, the permeability-survey data will materially assist in determining

casing points, total depths, perforating programs, acidizing and shooting programs, and advisability of drilling edge locations. The development of the six-well lease reservoirs, their greatly varying permeability and the differences in the physical structure of the drainage channels, any simultaneous acid treatment of two or

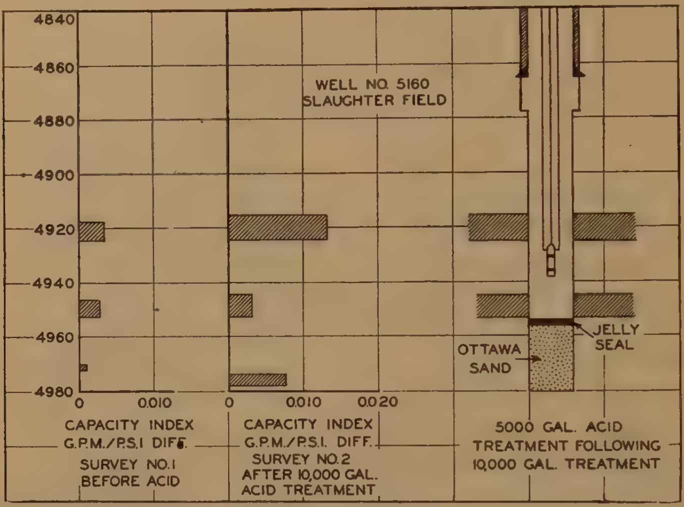

FIG. 5.—SURVEY AND SELECTIVE ACIDIZATION OF WELL IN SLAUGHTER FIELD WITH ELECTRIC PILOT

shown on the right-hand side of the Slaughter field cross section in Fig. 2 is interesting from this standpoint. All of these wells upon completion were surveyed with the Electric Pilot. Original plans were to drill the wells to a maximum subsea depth of minus 1520 ft.; however, after the first four wells had been drilled—Nos. 4884, 4919, 4954, and 5006 in the order listed—it appeared from the correlation of the Electric Pilot and geological data that well No. 5082 should be drilled to a lower subsea depth in order to penetrate the two lower zones shown in wells 4919 and 5006. By drilling deeper, these two zones were picked up in well 5082. This information gained from the correlation of Electric Pilot and geological data also led to the drilling of well 5160 deeper than originally was planned, although it was not drilled deep enough to penetrate the two lower zones appearing in other wells because of potential water hazards.

Owing to the very nature of limestone more permeable zones will generally result in the productivity of one or a part of the zones being greatly increased and the productivity of the others only slightly increased. Permeability surveys made before and after acid treatment have shown this to be true in most cases, and they have also shown that the zone or zones that had the greatest capacity before treatment may not also have the greatest capacity after treatment. At present, it is not always possible to predict which of several zones will be benefited most by a simultaneous acid treatment of all zones.

In order to obtain the maximum ultimate production and maximum production efficiency from a lime well, all permeable zones must be reasonably open, and there should not be too great a variation in the effective permeability of the various zones; particularly if the producing horizons are of a banded nature, as they appear to be in the Permian Basin.

The selective acidizing method to be used in any lime well will depend, of course, upon well conditions. However, where well conditions will permit it is recommended

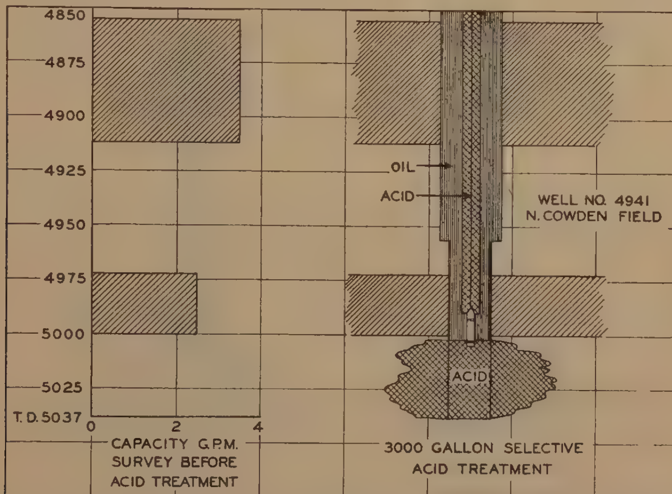

Fig. 6.—Survey and selective acidization of well in North Cowden field with Electric Pilot.

that a well be given a borehole wash acid treatment after completion and then surveyed with the Electric Pilot. If there are no extremely permeable zones, or zones that might possibly break down to very low treating pressures, the whole section should be acidized and then the well resurveyed to determine the increase in capacity of the individual zones. After the second survey an acidizing program for the treatment of any zones that have not been sufficiently increased in productivity can be decided upon. An alternative method is that of surveying the well after a borehole wash acid treatment and then successively treating each permeable zone from the bottom upward by successively plugging off each zone, after it has been treated, with a temporary plug, and using the Electric Pilot to keep the acid out of the upper zones during the treatment. However, this procedure is more costly and consumes more time than the first procedure mentioned.

One of the most interesting examples of selective acidizing with the Electric Pilot is a well in the Slaughter field, illustrated in Fig. 5. This well was surveyed with the Electric Pilot upon completion and three permeable zones were found. All zones were acidized simultaneously with 10,000 gal. of acid and a test after this treatment showed a potential of 700 bbl. of oil per day. The well was again surveyed and it was found that the capacity index of the upper zone had been increased by 230 per cent, that of the middle zone by only 6 per cent, and that of the lower zone 470 per cent. It appeared that the middle zone needed further acidization and consequently the bottom zone was blocked off with a temporary plug and the middle section was treated with 3000 gal. of acid; using the Electric Pilot to keep the acid out of the upper zone. Another 2000 gal. of acid was pumped into the two upper sections simultaneously. After this second acid treatment a test of the well showed a potential of 1137 bbl. per day, or a 437-bbl. per day increase.

One case in which the acidization of zones that were shown as impermeable by the

Electric Pilot has caused large increases in production is that of a well in the North Cowden field, illustrated in Fig. 6. A permeability survey on this well upon completion showed two permeable zones, from 4856 to 4912 and 4973 to 5000 ft. The sample log showed good saturation from 5000 to 5037 ft. The well had a potential of 3 bbl. per hour upon completion. The bottom section of the well from 5001 to 5037 ft., was selectively treated with 3000 gal. of acid, using the Electric Pilot to confine the acid to the bottom section. A casinghead pressure of 1500 lb. per sq. in. was required to inject acid into this section. Following this treatment the well was tested and it showed a potential of 15 bbl. per hour—a 4000 per cent increase. The lower section, from 5000 to 5037 ft., was then temporarily plugged off and the upper zone was acidized with 4000 gal. of acid. A casinghead pressure of 700 lb. per sq. in. was required to inject the acid into this section. This acid treatment increased the potential of the well by only about 10 per cent. It is doubtful whether simultaneous acidization of the entire pay section by conventional means would have caused an appreciable increase in the potential of the well, owing to the great difference in the original capacity of the upper and lower sections.

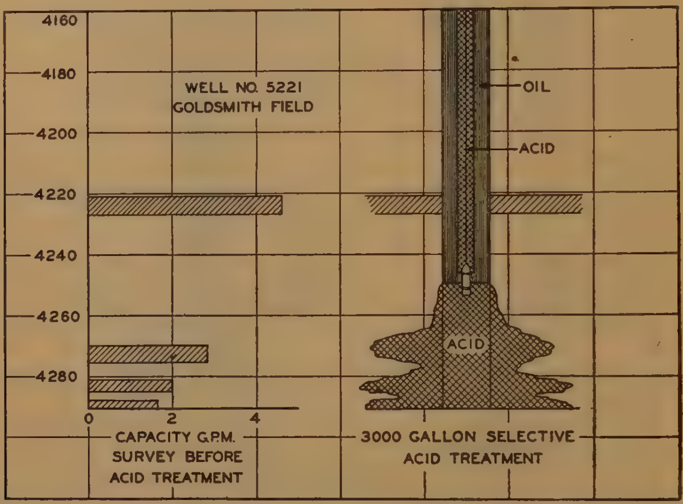

FIG. 7.—SURVEY AND SELECTIVE ACIDIZATION OF WELL IN GOLDSMITH FIELD WITH ELECTRIC PILOT.

In workover operations to exclude water or gas from wells, the knowledge of the position, thickness and capacities of the permeable zones in the well is particularly important. While the Electric Pilot itself will not tell whether a zone contains oil or water or gas, the information as to the position, thickness and relative capacities of each of the permeable zones, along with other well information such as that gained from temperature surveys, or the position of gas or water in near-by wells, will greatly assist the operator in planning a workover program.

An interesting example of the use of the Electric Pilot in workover operations is the work done on a well in the Goldsmith field (Fig. 7). Upon completion, the entire lime section below the casing seat was treated with 7000 gal. of acid, making a high gas-oil ratio well. The gas-oil ratio on this well increased gradually and on the production test just prior to workover operations the well made 27½ bbl. of oil

per day on an 8⁄64-in. choke with a gas-oil ratio of 5385:1. The well was surveyed with the Electric Pilot and four permeable zones were found, the upper zone having the greatest capacity. Following the survey, the three lower permeable sections were selectively treated with 3000 gal. of acid, using the Electric Pilot to confine the acid to the bottom sections. This treatment increased the oil production sufficiently so that on a production test after the acid treatment the well made 69½ bbl. of oil per day on a ¼-in. choke, with a gas-oil ratio of 1370:1; well below the penalty stage for the field.

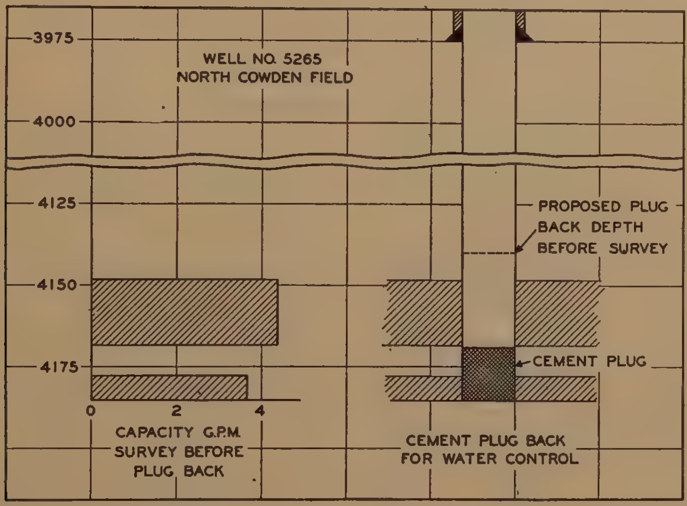

FIG. 8.—ELECTRIC PILOT SURVEY AND CEMENT PLUG-BACK JOB ON WELL IN NORTH COWDEN FIELD.

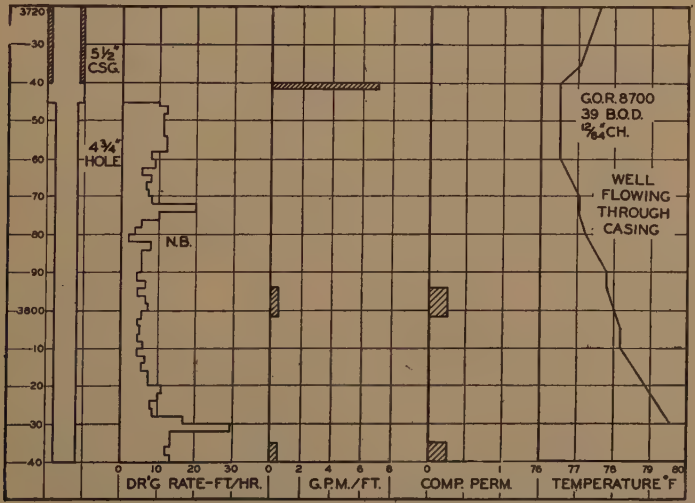

FIG. 9.—ELECTRIC PILOT AND TEMPERATURE SURVEY ON HIGH GAS-OIL RATIO WELL IN EUNICE FIELD PRIOR TO WORKOVER OPERATIONS.

A well in the North Cowden field (Fig. 8) went to water and just prior to workover operations was making 98

per cent water on the pump. The drilling-time log on the well showed a rather uniform rate of penetration throughout the entire 211 ft. of section below the pipe, so that this log offered little information in regard to the source of the water. Original workover plans, based upon a study of water-oil contacts in near-by wells, were to plug the well back to 4140 ft. with cement, but before plugging the well back the operator surveyed the well with the Electric Pilot. Two permeable zones were found in the well from 4148 to 4169 and 4178 to 4185 ft. As a result, the plug-back program was changed and the well was plugged back only to 4169 ft. The last report on this well, after it had been produced for about 10 days after the plug-back, was that the well was flowing about 160 bbl. of oil per day with 30 to 40 per cent water, and the water percentage was decreasing.

The use of the Electric Pilot survey along with information obtained from other sources, such as temperature surveys, core logs, etc., for planning a workover program is well illustrated in the case of a well in the Eunice field of New Mexico (Fig. 9). This is a high gas-oil ratio well, which on a recent production test made 39 bbl. of oil per day on a 12/64-in. choke with a gas-oil ratio of 8700:1. A temperature survey on this well indicated that the gas was coming into the hole between 3740 ft., the casing seat, and 3760 ft. An Electric Pilot survey of the well showed 49 per cent of the injected fluid going around the casing seat, and also showed permeable zones from 3793 to 3802 and 3835 to 3840 ft. Following these surveys, a formation packer was set at 3787 ft. to further test the well, and on a production test after setting the packer the well made 33 bbl. of oil per day with a gas-oil ratio of 1719:1. Results of these surveys and production tests indicate that a remedial squeeze-cement job to repair the leaky casing seat will lead to a low gas-oil ratio in the well.

Acknowledgments

The writers wish to thank the many operators and engineers concerned for permission to use specific data obtained at their wells; and for their suggestions and assistance in the gathering and preparation of the data.

An Experimental Water-flood in a California Oil Field

By E. C. Babson,* J. E. Sherborne,* and P. H. Jones,† Members A.I.M.E.

(Los Angeles Meeting, October 1944)

Abstract

A study of the Chapman zone in the Richfield field, Orange County, California, indicates that the quantity of oil recovered by present methods will be only a small portion of the oil originally in place. Since the volume of residual oil is believed to be of large magnitude, an experimental water-flooding operation has been initiated in order to determine whether water-flooding offers promise as an economical method of recovering some of this residual oil. A single injection well was drilled between old producing wells, and a water-treating plant using alum flocculation and chlorination was designed and built. Water has been injected into the input well for six months at rates in excess of 100 bbl. per day. Production from one of the neighboring wells has increased materially, the oil production having risen from 7 to 30 bbl. and the water from 1 to 40 bbl. per day.

While definite conclusions regarding the economic success of water-flooding in the Chapman zone are not justified at this time, it has been demonstrated that water can be injected into the zone on a sustained basis and that this water will displace appreciable quantities of oil from the sand.

Introduction

As a result of an investigation of subsurface conditions in the Chapman zone of the Richfield field, it was concluded that ultimate oil recovery from this zone would probably be low and that natural water encroachment was so localized as to be of little importance from a recovery standpoint. Furthermore, it was found that in many portions of the zone the wells were approaching an unprofitable level of production. When these data were presented to the management of the Union Oil Co., their reaction was that an attempt should be made to develop methods of recovering at least a portion of the large quantity of oil remaining in this zone.

After some investigation, it was decided that water-flooding offered the most likely means of accomplishing this end, but reservoir conditions in the Chapman zone differ so widely from those encountered in any of the flooding projects described in the literature that it was difficult to evaluate the probability of success. Despite encouraging results from laboratory tests, it was not even certain that water would displace an appreciable volume of oil from the Chapman sand under reservoir conditions. Therefore, it was decided to initiate a small-scale project, for two purposes: first, to determine whether water would displace oil from the Chapman sand and, second, to obtain information and experience for future operations if water-flooding appeared to be a promising method of secondary recovery.

Reservoir Data

The Chapman zone is the upper of the two producing zones in the Richfield field, being found at depths from 3000 to 3700 ft. The productive portion of the zone consists of a large irregularly shaped sand body, which is more than 400 ft. thick at the top of the structure. As the margin of the field is approached, the sand is replaced

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Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1816 in Petroleum Technology, March 1945.

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by interfingering shale members, until at some points the interval becomes predominantly shale. The sand is of medium grain size, friable, usually argillaceous, and poorly sorted; the average porosity is approximately 31 per cent, the average permeability to air approximately 1100 millidarcys, and the average interstitial water content is believed to be 37 per cent.[1] The oil ranges in gravity from 16° to 22° A.P.I., the average being about 19°. The viscosity of the oil, corrected to reservoir temperature of 140° but without adjustment for gas in solution, is approximately 50 centipoises. Oil recovery to date has been approximately 19 per cent of the oil in place and it is expected that the ultimate recovery by present methods of production will be between 21 and 22 per cent of the oil in place. The principal recovery mechanism has apparently been expansion of originally dissolved gas. Water encroachment has been localized to certain areas in the field and in certain portions of the section as would be expected from the irregular nature of the sand body.

In choosing a location for a water-flooding experiment, several factors were considered. In the first place, a thin sand section was desired, in order to minimize damage if the project were unsuccessful. Secondly, it seemed reasonable to choose a location in which water encroachment had been absent. Thirdly, it was considered desirable that the wells in the area to be flooded should be approaching an unprofitable level of production. In addition to these features, it was, of course, necessary that the project be located in such a manner as to minimize offset difficulties.

The location chosen is in the southwestern part of the field, not far from the pinch-out of the Chapman sand. The sand body at this location is approximately 50 ft. thick and the two producing wells nearest to the injection well were each producing approximately 7 bbl. per day of oil and 1 bbl. per day of water prior to inception of the project. A section through the input well and these two producing wells is shown in Fig. 1.

[1] H. C. Pyle and P. H. Jones: Amer. Petr. Inst. Drill. and Prod. Practice (1936) 171.

Development

As the underlying Kraemer zone was believed to be productive at the location chosen for this experiment, the input well *A* was drilled to this zone in order to make possible recompletion as a Kraemer-zone producer following conclusion of the water-flooding project. The Chapman sand body was completely cored and detailed core analyses were made, the results of which are shown in Fig. 2. The sand body was somewhat thinner than was expected, there being only 38 ft. of sand in the section and the average permeability and porosity were lower than the averages for the zone as a whole, the permeability to air being 422 millidarcys and the porosity 29.1 per cent. The well was completed by running a 5½-in. combination string to bottom, cementing through perforations at the base of the Kraemer shale and gun-perforating the Chapman sand. In order to protect the Kraemer zone, the cement and retainer left from the cementing operation were not drilled up, and, as a further precaution, a bridge plug was set below the Chapman sand.

After swabbing perforations and bailing for a few days, pumping equipment was installed and the well was put on production. Over a period of three weeks, the production averaged approximately 4 bbl. per day of net oil with a cut of 20 per cent and a gravity of 18.2° A.P.I. In order to ensure adequate cleaning of the sand face, the well was then washed with 250 gal. of inhibited hydrochloric acid. Although some mud was bailed from the well following this treatment, production from the well was not increased. After a few weeks' further production, the rods and tubing were pulled and 2½-in. cement-lined tub-

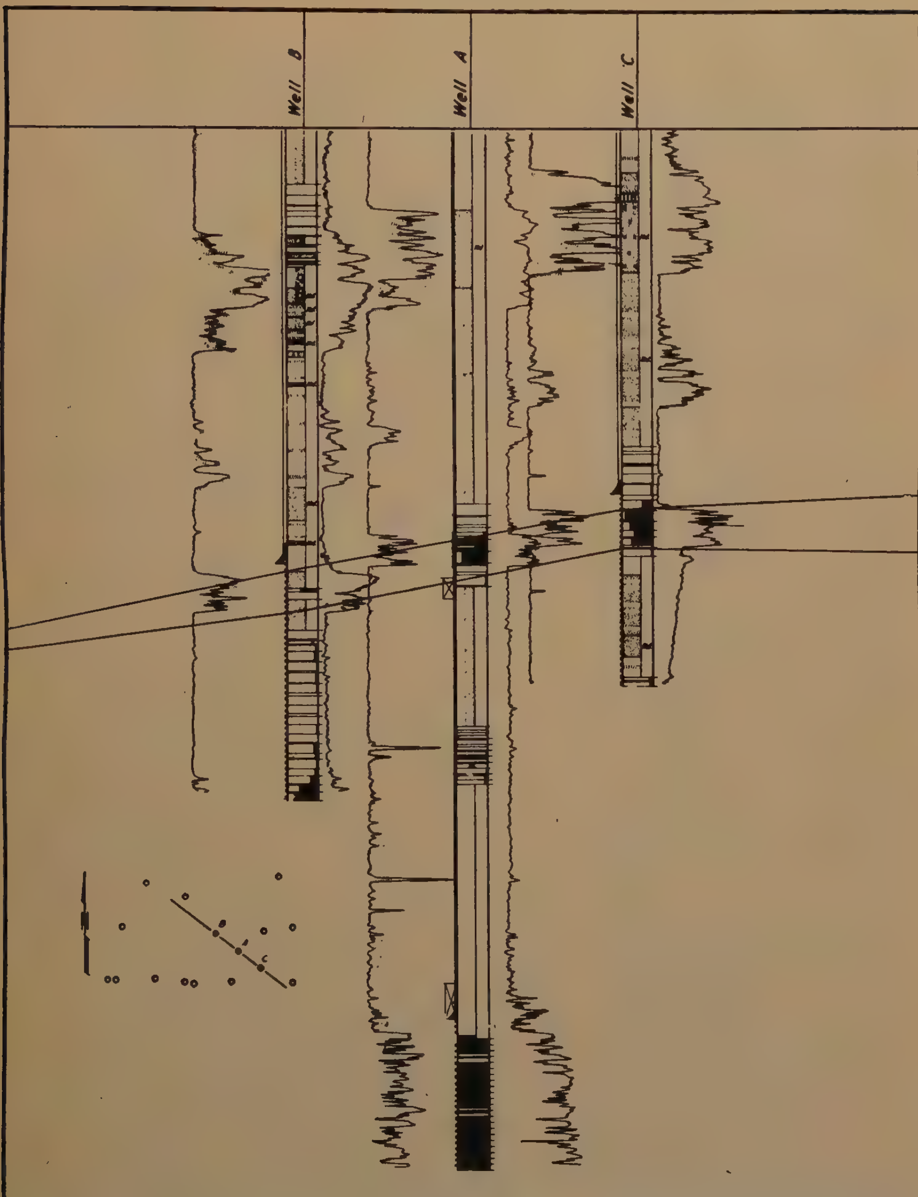

FIG. 1.—SECTION THROUGH INJECTION AND ADJACENT WELLS OF THE EXPERIMENTAL WATER-FLOOD.

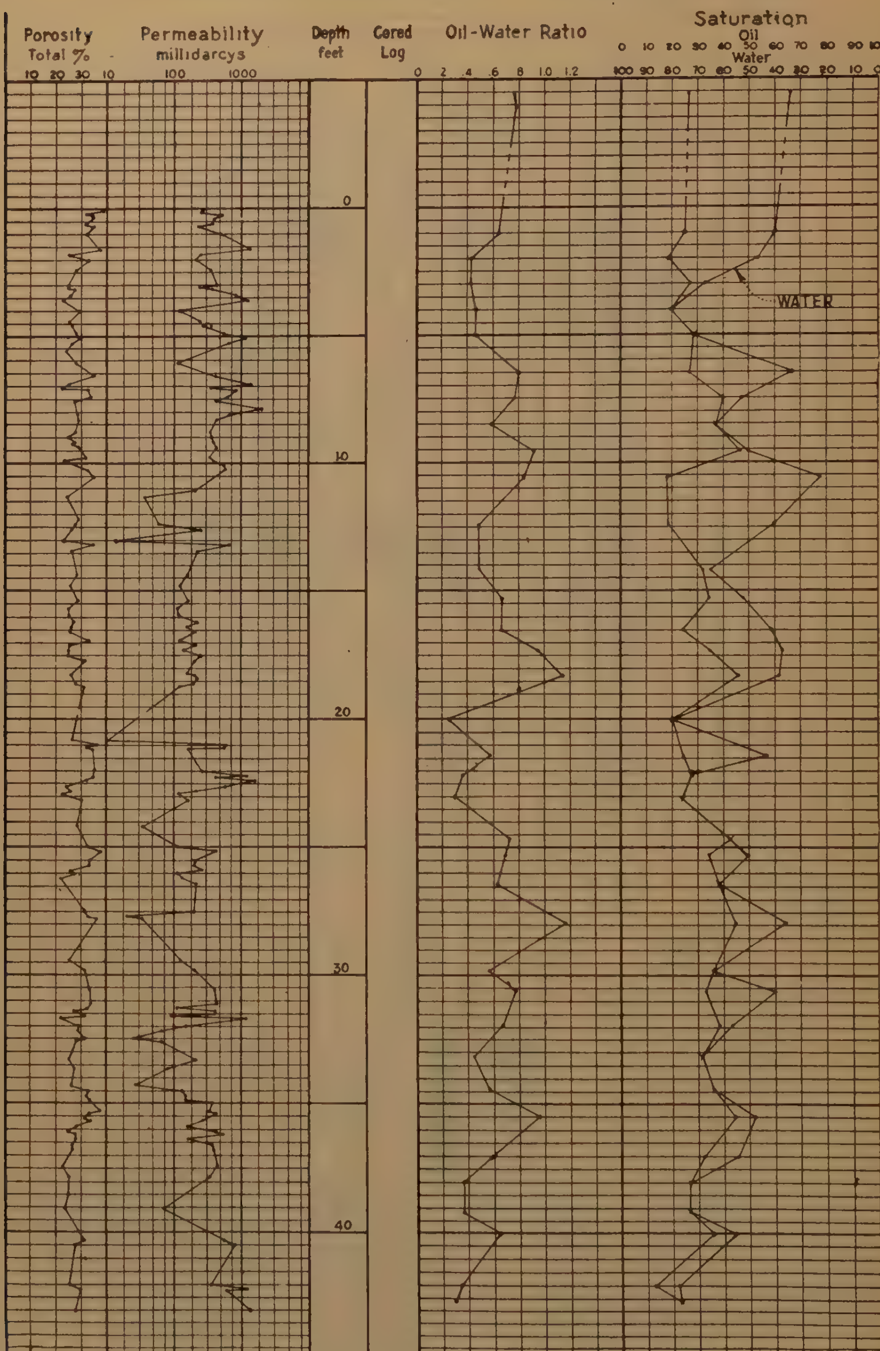

FIG. 2.—CORE ANALYSIS LOG OF INJECTION WELL A.

ing was run with a packer set a few feet above the perforations.

Water Treatment

By far the most logical supply of water for injection is the waste water that is produced from the Richfield oil field itself. Water from the Chapman zone is much fresher than that produced from the Kraemer. Typical analyses of these two waters (Table 1) show that the salt content of the Kraemer water is about four times as great as that of the Chapman water. Since the production from both zones is treated in a common dehydration plant on each lease, it is not feasible to separate the waters and therefore all of the water is collected into a common disposal system.

Table 1.—*Typical Analyses*
Per Cent

Radical	Chapman	Kraemer	Composite[a]
Sodium	1,978	8,113	3,963
Calcium	68	204	162
Magnesium	28	148	46
Sulphate	35	18	26
Chloride	2,766	13,040	6,276
Carbonate	0	216	
Bicarbonate	1,089	0	409
Silica	64		
Iron and aluminum as R_2O_3	12		3
Total solids	6,050	21,729	10,885
pH	8.8		8.1

[a] The composite sample contained 37 p.p.m. oil and 8 p.p.m. of finely suspended solids.

Preliminary tests indicated that core samples from the Chapman zone were plugged by either the untreated water or a water that had been thoroughly filtered. The water was found to contain a great deal of flocculable material, but even after flocculation with alum it still exhibited a large demand for oxygen. Subsequent tests have shown that thorough oxidation of the water is necessary in order to prevent plugging of the core samples. While the use of fresh water might render unnecessary the complex treatment required for the waste water, experience with California oil sands indicates that fresh water often has a deleterious effect on the sand permeability.

Consequently, a small pilot plant was erected for the purpose of developing an adequate treatment for the waste water. As a result of experimentation with this plant, it was concluded that the production of a satisfactory water required the following steps:

1. Primary flocculation with alum to remove the bulk of the suspended matter, which, in itself, had a high oxygen demand.
2. Oxidation of soluble organic material to a form that can be flocculated.
3. Secondary flocculation with alum.
4. Filtration.

In consideration of the economics of water treatment and the uncertainties involved in an experimental project of this nature, a plant was constructed to treat a maximum of 1000 bbl. of water per day, using the process outlined. Although the central waste-water disposal facilities are about ⅜ mile from the injection well, it was found desirable to treat the water at that place rather than at the well, since this procedure would facilitate the removal of sludge and waste material and would minimize the danger of damage to the orange trees that surround the injection well.

In designing the plant, advantage was taken of the topography to provide for gravity flow, as far as this was possible, and an effort was made to make the process automatic. As shown in the flow diagram, Fig. 3, water flows by gravity from the efflux of the skimming pond of the central waste-water system to a raw-storage basin, from which it is pumped by a centrifugal pump into the primary flocculator. Alum is proportioned into the flow stream just before it enters the flocculator, in which a uniform floc is formed as the water rises through a central compartment under gentle agitation. The stream then passes over the rim of this cylinder and down through the

annulus between it and a cylindrical shield under which the water passes into the main settling space of the flocculator. This primary flocculator is small in tank shut off the raw-water feed pump, the primary flocculator, and the chlorinator when the tank is full, and start the process when the level falls.

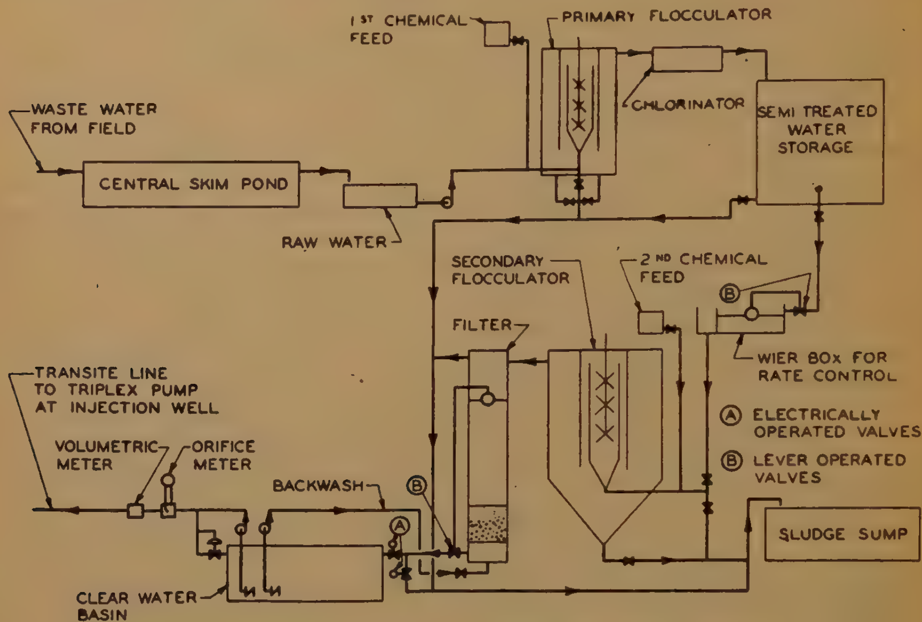

FIG. 3.—FLOW DIAGRAM OF TREATING PLANT FOR EXPERIMENTAL WATER-FLOOD.

relation to the amount of fluid it must handle, since it is designed only to eliminate the bulk of the suspended matter. Sludge is drawn from the bottom of the flocculator manually once each 24 hr. It is found to contain, as might be expected, a considerable amount of oil and finely divided sediments.

Water discharges from the top of the flocculator settling chamber directly into a trough, in which the water is forced to pass between closely spaced carbon electrodes. Direct current supplied by a d.c. generator at 4 to 6 volts produces chlorine and derivative substances from the chloride ions already present in the water. The chlorinated water emerges from the electrolytic cell into a storage tank, from which it flows as required to the final flocculator. Float controls on this

Flow by gravity from the storage tank containing semitreated fluid to the secondary flocculator is controlled by a float in a narrow (8°) V-notch weir box. The float operates a standard lever valve on the pipe at the entrance to the weir box. Alum is added to the water at this point and the mixture passes directly into the inner chamber of the flocculator. Flow through this unit is similar to that through the primary flocculator. Provision has been made for adding other chemicals to neutralize the chlorine and improve the flocculation, but the use of these is not deemed necessary at present.

From the top of the secondary flocculator, the water enters the filter, moving downward through a sand bed and out the bottom into the basin for storing clear water. A lever valve on the filter outlet,

operated by a float in the filter, assures a positive head of water over the sand bed at all times. When the filter plugs, the rising of a second float operates an electrical

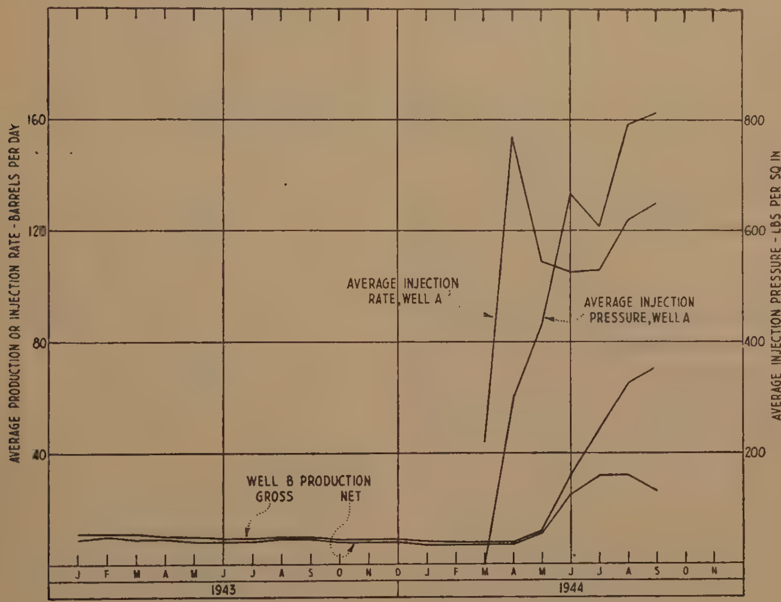

FIG. 4.—INJECTION AND PRODUCTION HISTORY OF WELLS A AND B.

timing switch, which, at predetermined intervals of time, causes:

1. The closing of an electrically operated valve on the filter outlet to the clear-water storage.

2. The starting of the back-wash pump.

3. The stopping of the back-wash pump.

4. The opening of an electrically operated valve from the filter outlet to the sludge sump.

5. The closing of the valve to the sludge sump and the opening of the valve to the clear-water well.

At the time the plant was designed, it was thought that back-washing would be required as often as every other day. However, at the slow rate at which the water is being treated at present (about 15 per cent of the designed capacity), back-washing is required only about once every 20 days.

Water from the clear-water storage basin is pumped through 3500 ft. of 3-in. Transite line to the suction of a Triplex pump at the injection well. A constant pressure on this line is maintained by a back-pressure regulator, which returns excess water to the clear well. The injection rate is controlled by means of another back-pressure regulator, which by-passes water from the discharge into the inlet line to the Triplex pump. Both an orifice and a volumetric meter measure the water injected, in order to provide means of checking the injectivity characteristics of the well.

Since the system is designed to operate unattended, a low-pressure cutout stops the gas engine that drives the Triplex if the suction pressure falls. Float switches on the semitreated storage, filter, and clear-water storage operate an alarm system designed to attract the field operator if the plant fails to operate properly. The warning devices are so set that the field operator will have ample

time to respond, even though he is not in the immediate vicinity of the plant.

Since the water-treating operation is of an experimental nature, a considerable number of tests have been made on the plant performance and the quality of the water produced. While the results of many of these tests are as yet inconclusive, certain interesting phenomena have been observed. For instance, although the available data show that water leaving the chlorinator is completely sterilized, microorganisms reinhabit it so rapidly that the bacteria count of the injected water is many times that of the raw water. Although these can be readily detected in the laboratory and, in fact, will plug a sintered glass disk, there is no definite evidence that they have caused any appreciable plugging of the formation or well bore.

Water-injection Operations

After completion of the water-treating plant and a period of experimentation, water injection was started on March 29, 1944. Average data on water-injection rates and pressures since that time are shown in Fig. 4, from which it can be seen that the injection rate showed a marked tendency to decline during April and May. However, the rate has remained relatively constant since June, except for the increase in August resulting from an increase in injection pressure from 610 to 790 lb. per sq. in. Injection rates during May and June were somewhat irregular, owing to difficulties encountered in the operation of the Triplex pump.

Because it was difficult to predict the pressure required for injection, it was considered desirable to install a pump that could be used elsewhere in production operations if it were not needed for this project. For this reason a Kobe Triplex pump was chosen. Since the pump was to handle brine, it was felt that external lubrication might be necessary to prevent scoring of the close-fitting plunger and liner assembly. In actual operation it was found that adequate lubrication could not be obtained without contamination of the injected water. This difficulty was overcome by the use of chevron-type packing around the plunger in conjunction with gravity-feed lubrication. Since these changes have been made, the performance of the pump has been entirely satisfactory.

Table 2.—*Summary of Water-injection Operations*

Date	Well A		Well B		
	Water Injection, Bbl.	Average Pressure, Lb. per Sq. In.	Production, Bbl.		Water Cut, Per Cent
			Oil	Water	
1944					
March	132	Vac.	226	28	11.0
April	4,607	296	210	30	12.5
May	3,162	431	333	38	10.2
June	3,164	667	758	207	21.5
July	3,170	607	945	532	36.0
August	3,840	792	927	957	50.8
September	3,909	812	774	1,360	63.7

At the present time, only well *B*, shown on the section in Fig. 1, has been affected by water injection. The production history of this well is shown in Fig. 4. Oil production from well *B* began to rise about the middle of May and has increased from approximately 7 bbl. per day to 30 bbl. per day. While the cut has been rising quite rapidly, the well has produced almost 3000 bbl. of oil in addition to that which normally would have been produced. Statistics on the water injected into well *A* and the production from well *B* are shown by months in Table 2.

Conclusion

While it cannot be stated positively at this time that water-flooding will be economically successful in the Chapman zone at Richfield, it has been demonstrated that water can be injected into the zone on a sustained basis and that this water

will displace appreciable quantities of oil from the sand.

Acknowledgments

The authors gratefully acknowledge the many helpful suggestions of Basil P. Kantzer, who has directed their activities during the operation of this project. The studies of E. R. Atwill and M. G. Arthur on reservoir conditions, and the work performed by Ray Rogers and C. F. Bowden in the development of the water treatment, have been invaluable contributions to this project. The authors are grateful to the management of the Union Oil Co. for permission to publish this paper.

DISCUSSION

T. A. Pollard.*—The Union Oil Co. and its engineers are to be highly complimented for their pioneering in the field of water-flooding in California. Adverse opinions have been expressed in the past about the practicability of water-flooding in California fields, and it is therefore encouraging to observe an operator who is willing to try out the method.

I should like to ask the authors several questions:

1. Are they willing to hazard an estimate of the effective permeability of the sands to the reservoir oil, in the area of the test project?

2. Has any back flow, bailing, or other clean-out procedure been necessary on the injection well?

The graphical data indicate that there is some uncertainty whether the peak of the stimulated production from well B has yet been reached, and it is therefore not possible to make an estimate of the ultimate increased recovery to be expected from the well, based on the production curve alone.

The data seem to indicate rather clearly that some by-passing of injected water to well B must have taken place already, since the amount of water injected to date is sufficient to fill only the available reservoir volume underlying an area of one acre, assuming that half the hydrocarbon space has been uniformly swept out. Interesting future developments will therefore be the success of methods used to control by-passing of the injected water.

The nature and scale of this project show that it should be regarded more as a pilot operation than as a full-scale project. This is true for two reasons:

1. Only one injection well is being used, whereas in other water-flooding projects there are sometimes as many injection wells as producing wells.

2. Only one tenth of the possible thickness of this reservoir is being used. If results for the pilot operation are successful, greater thicknesses of sand could be flooded at other locations in the reservoir at little more cost than attends this initial operation.

For these reasons, those of us outside the Union Oil Co. should not hastily conclude in the future that this pilot operation is a failure if the costs of drilling the injection well and building a water-treatment plant are not fully returned. Whether or not this project is in itself economic, there are several important things that can be learned from the test:

1. As the authors have pointed out, it has already been proved that (*a*) water can be successfully injected into the zone at satisfactory rates, and (*b*) oil can be displaced from the zone.

2. The recoveries obtained per acre-foot may show satisfactory economics obtainable by flooding thicker sections at small increased costs.

3. The success of methods used in the future for shutting off water selectively so as to control the spread of injected water in streaks of varying permeability.

4. The ability to flood oils having a viscosity as high as 50 cp. Some engineers have questioned the feasibility of this in the past.

5. The ability to flood economically reservoirs for which the permeability-viscosity ratio appears to be less than 10 and perhaps as low as 2 (with respect to the oil phase).

E. C. Babson (author's reply).—The effective permeability of the sand to reservoir oil is not known but it is probably very much lower than the air permeability of 422 millidarcys.

The well has not been bailed or cleaned out since injection was started. At one time, injection was shut off and the well-head pressure bled down in order to replace the tubing head and reseat the packer.

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Average Permeabilities of Heterogeneous Oil Sands

By W. T. Cardwell, Jr.,* and R. L. Parsons,* Junior Members A.I.M.E.

(Los Angeles Meeting, October 1944)

Abstract

This paper discusses the practical problem of estimating a single equivalent permeability for an oil reservoir, or a portion thereof, whose actual permeability varies in an irregular manner. Limiting averages for general types of permeability variation are developed, and illustrated by examples involving important, specific types of variation.

Introduction

The theory of the flow of fluids through porous media[1-4] is becoming increasingly important in predictions of oil-reservoir behavior. In practical applications, however, reservoirs are seldom found to which simple theory strictly applies. Actual reservoirs have complicated shapes and nonuniform permeabilities and porosities.

This paper discusses the problem of estimating a single equivalent permeability for an oil reservoir, or a segment of an oil reservoir, whose actual permeability varies in an irregular manner. The equivalent permeability of a reservoir segment is defined as the permeability of a homogeneous segment of the same dimensions that would pass the same flux under the same pressure drop. It is the permeability value that can be used in simple theoretical formulas to calculate the reservoir behavior.

To the authors' knowledge, previous theoretical calculations† on systems of nonuniform permeability have been carried out only by Muskat[1a]; and he has not dealt with irregular variations, except in writing down the general differential equation for the pressure in variably permeable systems.[1b]

In practical work, many calculations necessarily have been made to estimate equivalent permeabilities from the permeability profiles obtained by core analyses. Regarding such calculations, Johnston and Sherborne[5] say:

> Simple arithmetic and weighted averages have been tried on many wells and it has been found that, where frequent sampling has occurred, the arithmetic average is as satisfactory as a weighted average. It is possible that the application of statistical methods to the analysis of permeability data as recently presented by Law[6] may prove fruitful.

Law has made a valuable contribution in showing how statistical analyses may aid in picturing the characteristics of a reservoir from those of a necessarily limited number of core samples. It is believed however that the particular problem of the estimation of equivalent permeabilities can be most directly approached from a fluid dynamical viewpoint as given in the present paper. An example is presented of the use of the conclusions herein in conjunction with Law's method.

Theory

In order to approach the problem of heterogeneity simply, it is interesting to consider a square block composed of four smaller, homogeneous, square blocks of porous medium, two of which have a

Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1852 in Petroleum Technology, March 1945.

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† Nonstatistical calculations are implied here. Concerning statistical calculations, see the references to Law.[6]

[1] References are at the end of the paper.

permeability k_1 and the other two a permeability of k_2. Fig. 1 shows such a block in the three possible arrangements of the component blocks. The blocks may be assumed to be of unit thickness perpendicular to the plane of the paper.

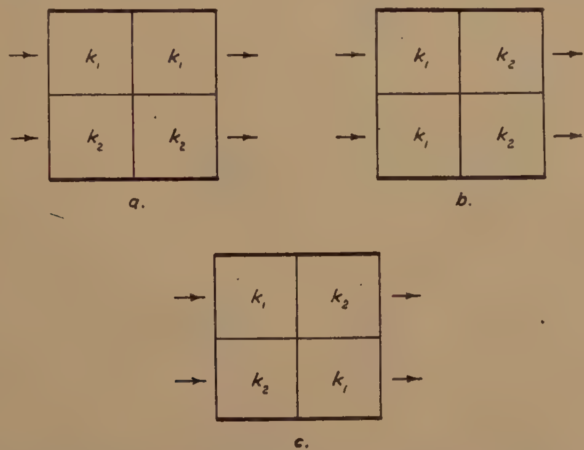

FIG. 1.—THE BLOCK COMPOSED OF FOUR SQUARES HAVING TWO DIFFERENT PERMEABILITIES.

Assume that through each of the arrangements indicated in Fig. 1 a fluid is caused to flow, from left to right through the block, by the application of a pressure drop from the left to the right side of the block. The top and bottom sides are assumed to be impermeable.

The equivalent permeability of the composite block of Fig. 1*a* under these conditions is the arithmetic average of the permeabilities k_1 and k_2:

$$\frac{k_1 + k_2}{2}$$

The equivalent permeability of the composite block of Fig. 1*b* is the harmonic average of the permeabilities k_1 and k_2:

$$\frac{2}{\frac{1}{k_1} + \frac{1}{k_2}}$$

The equivalent permeability of the composite block of Fig. 1*c*, through which there is oblique flow, cannot be easily calculated. It can be most readily determined by an electrical analogy experiment. The results of a series of such experiments, plotted in Fig. 2, show that the equivalent permeability of the composite block of Fig. 1*c* lies between the harmonic and arithmetic averages of the permeabilities k_1 and k_2.

Fig. 2 shows how the equivalent permeabilities of the three arrangements of Fig. 1 vary with the ratio of the two permeabilities.

It is shown in the Appendix that in the general case of a block of porous medium involving any number of different permeabilities and any type of directional variation, the equivalent permeability still lies between a harmonic and an arithmetic average of the actual permeabilities. In the general case, the permeabilities are weighted according to the respective volumes they occupy; and when the average flow is of a radial character, like that around a well, the permeabilities are also weighted according to their distances from the well.

Application

Equivalent Permeabilities Inferred from Core Samples

As shown in the Appendix, the equivalent permeability of the formation around

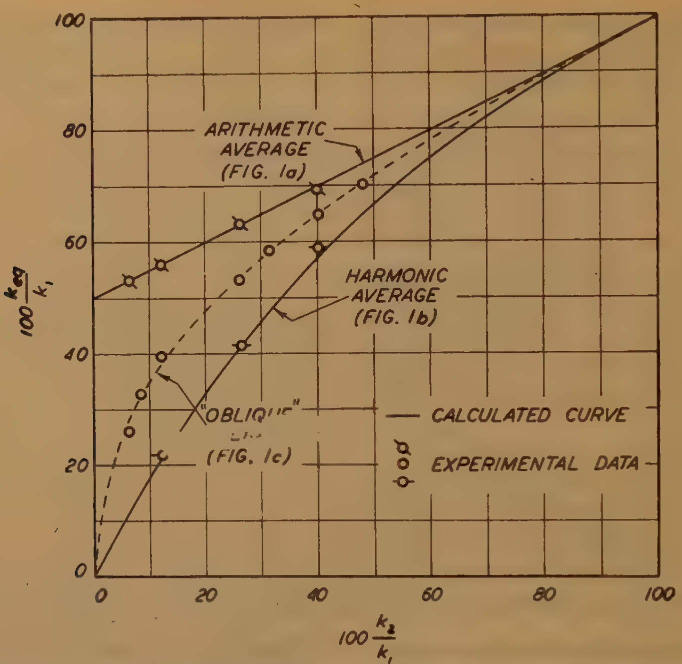

FIG. 2.—VARIATION OF THE EQUIVALENT PERMEABILITIES OF FIG. 1 WITH THE PERMEABILITY RATIO.

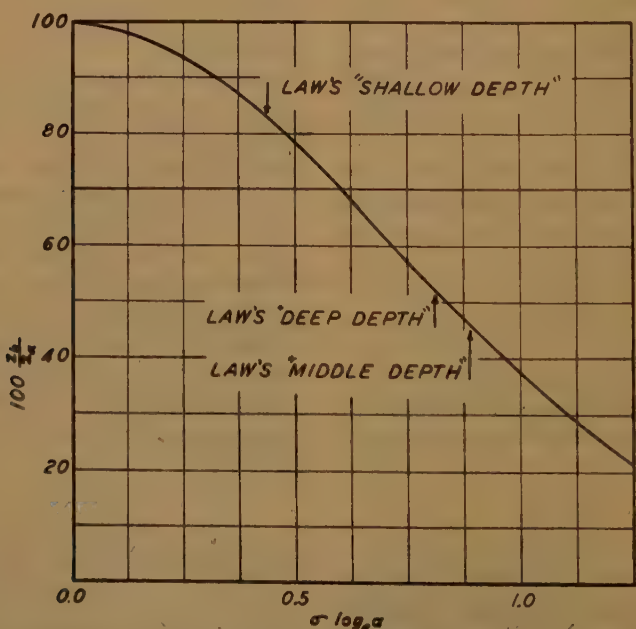

FIG 3.—RATIO OF THE HARMONIC TO THE ARITHMETIC AVERAGE PERMEABILITY IN LAW'S TYPE OF PERMEABILITY DISTRIBUTION.

a well bore lies between a volume-harmonic and a volume-arithmetic average of the actual permeabilities weighted as the inverse squares (or higher powers) of their distances from the axis of the well. Since the permeabilities in the regions immediately surrounding the well bore are so overwhelmingly important, and since it is usually reasonable to assume that core samples are representative of the formation immediately surrounding the bore-hole, it is reasonable to assume as a practical approximation that the equivalent permeability of the formation around a well bore lies between a volume-harmonic and a volume-arithmetic average of the core-sample permeabilities. Furthermore, since the cores may be considered to have the same cross-sectional area, the volume averages may be transformed into depth averages. Letting $\Delta_i h$ represent the depth interval over which a certain permeability k_i exists, the equivalent permeability may be assumed to lie between the following values:

$$\frac{\sum_i \Delta_i h}{\sum_i \frac{\Delta_i h}{k_i}} < k_{eq} < \frac{\sum_i k_i \Delta_i h}{\sum_i \Delta_i h} \qquad [1]$$

In words, the equivalent permeability is larger than the ratio of the total depth interval to the sum of the individual depth intervals divided by their corresponding permeabilities; and it is smaller than the ratio of the sum of the individual depth intervals multiplied by their corresponding permeabilities, to the total depth interval.

It is to be noticed that if a single interval of zero permeability is included in the calculation of the harmonic average, that average will be zero; while a zero permeability value will not greatly affect the arithmetic average. It is desirable to omit zero permeability values in the calculation of both averages.

It is interesting to estimate how far apart in numerical value the harmonic and arithmetic averages of actual permeability distributions will be in practice. The closeness of the harmonic and arithmetic averages will depend on the dispersion of the permeability values. This point may be conveniently investigated using the type of permeability distribution described by Law.[6] It is reasonable to assume that other permeability data than those considered by Law comply with the same general type of probability distribution. Law has found that permeability data fit the following frequency function:

$$\frac{dP}{d\log_a z} = \frac{100}{\sigma\sqrt{2\pi}}\, e^{-\frac{1}{2}\left(\frac{\log_a z - \log_a z_m}{\sigma}\right)^2} \qquad [2]$$

Where: P = percentage of permeabilities having a value less than Z.
z_m = geometric mean permeability.
a = an arbitrary logarithmic base.
σ = the standard deviation, which measures the spread of the permeability values.

From Eq. 2, the harmonic and arithmetic average permeabilities z_h and z_a may be calculated and expressed as in Eqs. 3 and 4:

$$z_h = z_m e^{-\frac{(\sigma \log_e a)^2}{2}} \qquad [3]$$

and

$$z_a = z_m e^{\frac{(\sigma \log_e a)^2}{2}} \qquad [4]$$

The ratio of these two quantities is plotted in Fig. 3 as a function of the standard deviation σ and the natural logarithm of the logarithmic base a to which it is referred.

Fig. 3 shows that if the standard deviation is zero, the harmonic and arithmetic averages are identical. This is, of course, to be expected, since all of the permeability values are identical. As the dispersion of the values increases, the harmonic average becomes a lower percentage of the arithmetic average.

Fig. 3 covers the range of standard deviations found necessary by Law to

describe the actual permeability distributions that he considered. In this range the harmonic average drops to one fifth of the arithmetic average.

No simple mathematical considerations can indicate whether the equivalent permeability of a complex formation lies nearer the upper, arithmetic average limit, or the lower, harmonic average limit. However, in the application of these results to oil-producing sands there is a good reason to favor the upper limit. As Muskat has indicated,[1c] if the lithological variations in an oil sand were strictly in a vertical direction, the equivalent permeability would be identical with the arithmetic average permeability, and actual variations are predominantly of the vertical type.

General Discussion

The considerations of this paper have led only to the establishment of upper and lower limits for the equivalent permeability; and these limits may differ by many per cent in numerical value. However, the established limits should serve as useful guides in reservoir analyses.

The discussion of Johnston[8] indicates a type of question that has existed. Johnston has stated that a body of sand consisting of equal portions of 100-millidarcy and 10-millidarcy sands might be arranged in thin, alternating, horizontal strata so as to have an equivalent permeability of 99 millidarcys, because of the possibility of oblique flow. Actually, the arrangement of Johnston, involving only vertical permeability variations, would not produce oblique flow per se, and the equivalent permeability would be the arithmetic average, 55 millidarcys. This is in accordance with the already cited statements of Muskat.[1c] The analysis of the present paper has shown that even if the two sands of Johnston were arranged so as to have mixed, horizontal and vertical variations, which would produce oblique flow, the equivalent permeability would not increase above the arithmetic average, but would decrease toward the harmonic average, 18 millidarcys. (This assumes no preferential placement of the higher permeabilities nearer the well bore.)

The present analysis also shows that the considerations of Law[6] regarding prediction of the productivity index might have greater physical significance if his geometric average permeability, which lies between the harmonic and arithmetic averages, were used, or perhaps if the arithmetic average itself were used. Law's predictions implicitly involved the root mean-square average, which is always greater than the corresponding arithmetic average.

Summary

1. The equivalent permeability of a heterogeneous oil sand lies between a harmonic volume average and an arithmetic volume average of the actual permeabilities, the volume elements in these averages being weighted according to the inverse squares (or higher powers) of their distances from the well.

2. For practical purposes, when the permeability variations away from a well are unknown, it is reasonable to assume that the equivalent permeability of a heterogeneous oil sand lies between the harmonic depth average and the arithmetic depth average of the core-sample permeabilities (see Eq. 1).

3. Qualitative reasoning, based on known reservoir characteristics, indicates that the equivalent permeability lies nearer to the upper, arithmetic limit than to the lower, harmonic limit.

Acknowledgment

The authors are grateful to the management of the Standard Oil Company of California for permission to publish this paper, especially to Mr. E. G. Gaylord. The suggestions of Dr. M. B. Standing

and other members of the Production Technology Laboratory staff were of assistance.

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Mathematical Appendix.—*The Limiting Values of the Equivalent Permeability*

Consider first a cubical block of variably permeable medium. Let Cartesian coordinate axes be represented by three intersecting edges of the block. Let a fluid be forced through the block by the application of a pressure drop between the faces perpendicular to the x axis. Assume no flow through the remaining faces.

It is desired to calculate upper and lower limits for the equivalent permeability of the block, the equivalent permeability being defined as the permeability of a homogeneous block of the same dimensions that would pass the same flux under the same pressure drop.

It is convenient to assume that the block of volume L^3 is divided by planes perpendicular to the x, y, and z axes, into N^3 very small cubes, each of which is small enough to be considered to have a constant permeability. Any one of these cubes may be denoted by three integers, l, m, and n, varying between unity and N, representing its distance from the origin (in numbers of cubes) in the x, y, and z directions, respectively.

In order to calculate an upper limit for the permeability of the large block, assume that the subdividing planes perpendicular to the x axis are surfaces of constant pressure. Physically, this would require that each of these planes be a very thin, very permeable lamina.

There is an electrical theorem[7] that states that if the conductivity of any element in a conductor is increased, the conductivity of the whole conductor will be increased, or remain unaltered. Since permeability variations in permeable media are mathematically analogous to conductivity variations in electrically conducting media,[1d] this theorem shows that the very thin, very permeable laminae of the last paragraph would increase or leave unchanged the equivalent permeability of the large block. So the equivalent permeability with such laminae present would be equal to or greater than the actual equivalent permeability.

If the sections of the block between the constant-pressure planes were very thin, the flow through those sections would be perpendicular to the constant-pressure planes and the conductivity of any interplanar section would be proportional to the sum of the permeabilities k_{lmn} of the small cubes, multiplied by their areas and divided by their thicknesses:

$$C_l = \sum_m \sum_n k_{lmn} \frac{\left(\frac{L}{N}\right)^2}{\frac{L}{N}} = \frac{L}{N} \sum_m \sum_n k_{lmn} \qquad \text{[A1]}$$

or, the resistance of the same interplanar section would be:

$$R_l = \frac{1}{C_l} = \frac{N}{L \sum_m \sum_n k_{lmn}} \qquad \text{[A2]}$$

The total resistance of the whole block would be:

$$R = \sum_l \frac{N}{L \sum_m \sum_n k_{lmn}} = \frac{N}{L} \sum_l \frac{1}{\sum_m \sum_n k_{lmn}} \qquad [A3]$$

So the equivalent permeability would be:

$$\frac{L}{L^2 R} = \frac{1}{N \sum_l \frac{1}{\sum_m \sum_n k_{lmn}}} \qquad [A4]$$

Since this equivalent permeability would be equal to or greater than the actual equivalent permeability, the following inequality may be written for the actual equivalent permeability (without the very thin, very permeable laminae):

$$k_{eq} \leq \frac{1}{N \sum_l \frac{1}{\sum_m \sum_n k_{lmn}}} \qquad [A5]$$

In order to calculate a lower limit for the equivalent permeability of the block, assume that the subdividing planes perpendicular to the y and z axes are streamlines. Physically, this would require that each of these planes be a very thin, impermeable lamina. According to a companion theorem of the one already used, such laminae would either decrease the equivalent permeability or leave it unchanged. So the equivalent permeability with such laminae present would be equal to or less than the actual equivalent permeability.

The resistance of any small, tubular section of the medium, bounded by impermeable laminae, would be proportional to the sum of the individual resistances along the tubular section:

$$R_{mn} = \sum_l \frac{1}{k_{lmn}} \frac{\left(\frac{L}{N}\right)}{\left(\frac{L}{N}\right)^2} = \frac{N}{L} \sum_l \frac{1}{k_{lmn}} \qquad [A6]$$

The conductivity of such a section would be:

$$C_{mn} = \frac{L}{N} \frac{1}{\sum_l \frac{1}{k_{lmn}}} \qquad [A7]$$

The conductivity of the whole block would be:

$$C = \frac{L}{N} \sum_m \sum_n \frac{1}{\sum_l \frac{1}{k_{lmn}}} \qquad [A8]$$

So the equivalent permeability would be:

$$C \frac{L}{L^2} = \frac{1}{N} \sum_m \sum_n \frac{1}{\sum_l \frac{1}{k_{lmn}}} \qquad [A9]$$

Since this equivalent permeability would be equal to or less than the actual equivalent permeability, the following inequality may be written for the actual equivalent permeability (without the very thin, impermeable laminae):

$$\frac{1}{N} \sum_m \sum_n \frac{1}{\sum_l \frac{1}{k_{lmn}}} \leq k_{eq} \qquad [A10]$$

Combining the two inequalities previously obtained, and altering their form slightly, one may write:

$$\frac{1}{N^2} \sum_m \sum_n \frac{N}{\sum_l \frac{1}{k_{lmn}}} \leq k_{eq} \leq \frac{N}{\sum_l \frac{N^2}{\sum_m \sum_n k_{lmn}}} \qquad [A11]$$

The unsymmetrical forms of this inequality are not amenable to easy interpretation. It is convenient to use some further inequalities to simplify the results.

The left-hand member of inequality A11 is an arithmetic average of harmonic averages, and it is not difficult to prove that it is equal to or greater than a purely harmonic average of the permeabilities concerned.

The right-hand member of inequality A 11 is a harmonic average of arithmetic averages, and it is not difficult to prove that it is equal to or less than a purely arithmetic average of the permeabilities concerned. So the interval of inequality A11 must lie within that of inequality A12:

$$\frac{N^3}{\sum_l \sum_m \sum_n \frac{1}{k_{lmn}}} \le k_{eq} \le \frac{\sum_l \sum_m \sum_n k_{lmn}}{N^3} \quad [A12]$$

Now it is convenient to multiply both the numerators and denominators of the right-hand and left-hand members of inequality A12 by the volume ΔV of the small cubes, to obtain, where V is the total volume of the block, inequality A13:

$$\frac{V}{\sum_l \sum_m \sum_n \frac{\Delta V}{k_{lmn}}} \le k_{eq} \le \frac{\sum_l \sum_m \sum_n k_{lmn}\Delta V}{V} \quad [A13]$$

Inequality A13 may be further simplified. Because of the simple nature of the summations, each of the N^3 values of the triple subscript lmn can be replaced by a single subscript i, and the triple summations changed into single summations. One may now write:

$$\frac{V}{\sum_i \frac{\Delta V}{k_i}} \le k_{eq} \le \frac{\sum_i k_i \Delta V}{V} \quad [A14]$$

Expression A14 states that the equivalent permeability of the cubical block under the conditions given is equal to or greater than the volume-harmonic mean and equal to or less than the volume-arithmetic mean of the actual permeabilities. The equality signs pertain only when all the individual permeabilities are equal and therefore are not important in the present considerations.

If the volume elements ΔV are made vanishingly small, the summations of expression A14 may be written as volume integrals:

$$\frac{V}{\int_{\text{vol}} \frac{dV}{k}} < k_{eq} < \frac{\int_{\text{vol}} k\,dV}{V} \quad [A15]$$

A Radial Case

Consider a block of variably permeable medium bounded by two coaxial, right circular cylinders, and two planes perpendicular to the axis of the cylinders. Let a fluid be forced through the block by the application of a pressure drop between the cylindrical faces. Assume no flow through the planar faces.

The equivalent permeability of such a block might be expected to be more dependent upon the permeability values near the smaller bounding cylinder than upon the values near the larger bounding cylinder.

By carrying out a calculation similar to that described above, one may derive the following expression for the equivalent permeability of the radial block:

$$\frac{\int_{\text{vol}} \frac{dV}{r^2}}{\int_{\text{vol}} \frac{dV}{kr^2}} < k_{eq} < \frac{\int_{\text{vol}} \frac{k\,dV}{r^2}}{\int_{\text{vol}} \frac{dV}{r^2}} \quad [A16]$$

The only difference between inequalities A15 and A16 is that in the latter there is a weighting according to the inverse square of the distance from the axis of the block. The equivalent permeability in the radial case, also, lies between a volume-harmonic and a volume-arithmetic average, the importance of the volume elements varying as the inverse squares of their radial distances.

Other Cases

The flow into an oil well may not occur from a block having the ideal boundaries of that treated in the last section. It

often approximates more closely the type of flow discussed by Muskat in his treatment of the partially penetrating well.[14] The flow converges more rapidly toward the well, being intermediate between radial and spherical flow.

More rapid convergence would cause the permeabilities in the vicinity of the well bore to become even more important in determining the equivalent permeability than is implied by expression A16; and the importance of other regions would decrease more rapidly than the inverse squares of their radial distances.

DISCUSSION

C. M. Beeson.*—Messrs. Cardwell and Parsons have made a definite contribution, which should prove helpful in interpreting core-analysis data. However, the gap between permeability and productivity is often very wide.

Provided permeabilities were measured with the formation water, the equivalent permeability of an interval should determine the capacity of that interval to conduct the water to the well, in the absence of any other fluid. When other fluid phases are present, the capacity to transmit any one of the fluids may be much less or even zero. In fact, the flow of one of the fluids may be in a direction opposite to the impressed pressure gradient, as in counter flow. Accordingly, it is conceivable that the oblique flow of one of several fluids may occur under a condition in which the oblique flow of a single fluid would be impossible.

J. Law.†—The problem chosen by Cardwell and Parsons is that of the establishment of a single equivalent permeability of a heterogeneous sand by the direct approach of fluid dynamics. Within the field of my limited critical ability, which falls far short of being adequate, the problem is uniquely conceived and with profound knowledge executed. Much that is obscure in my empirical paper is clarified by Cardwell and Parsons. The question arises as to the relative utility of a single equivalent permeability and of a centrally located permeability used in conjunction with a precise expression of spread. Assuming that the double expression permeability concept was amenable to fluid dynamic calculations, would it be your opinion, Mr. Parsons, that the aggregate effect of diminishing effect permeability in a heterogeneous sand would be best solved by the single or double system?

R. L. Parsons (author's reply).—Mr. Beeson is correct in pointing out the necessarily more complicated system resulting from the presence of two or more immiscible fluids. It is our opinion, however, that if relative instead of absolute permeabilities be considered the equivalent relative permeability would lie between the arithmetic and harmonic mean, and oblique flow would occur by the same laws that would cause oblique flow in an absolute permeability system.

Mr. Law asks which is of the greater utility in the definition of a variable permeability system, the equivalent permeability or a mean permeability and the standard deviation of the distribution. Remembering that our paper does not determine the equivalent permeability but only states that it lies between limits, both definitions would appear to be of use. Perhaps the greatest value of the equivalent permeability limits is to show that there is no type of permeability inhomogeneity that will result in an equivalent permeability greater than the weighted arithmetic average. Because our paper considers only the steady-state flow, this generalization does not follow for unsteady-state flow. However, it is our opinion, based on unsteady-state numerical solutions of permeability distributions most likely to give high equivalent permeabilities, that for steady or unsteady flow, the equivalent permeability will always lie between weighted arithmetic and harmonic means.

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Water Permeability of Reservoir Sands

By Norris Johnston,* Member A.I.M.E., and Carrol M. Beeson†

(Los Angeles Meeting, October 1944)

Abstract

For many years the permeability of reservoir sands has been measured by flowing air through a cleaned and dried core sample. This differs from the true reservoir permeability in one important respect: the rock particles in the reservoir are surrounded by interstitial water, not air, and their physical shape and condition of hydration are greatly dependent thereon. Permeability as defined must be measured with a single-phase fluid. Since no means exist for removing the oil and gas from a core sample by simply flowing water through it, the sample must be cleaned and then resaturated with water before testing. The present discussion attempts to show that after the cleaning process a considerably different permeability is determined with salt or fresh water than is obtained with air. The postulate is made that the salt-water permeability is probably closer to the true reservoir permeability than is the measurement with air. This is discussed in relation to both physically possible and economically feasible measurements. Data on more than 1200 core samples are given to show the nature of the effects observed, and a plea is made for others to consider water permeability measurements as a routine necessity, eventually replacing air permeability in regions where the differences are great.

Introduction

Permeability is defined[1] as "a measure of the capacity of a porous medium to transmit fluids, when there is no interaction between the solids and the fluid." Darcy's law of liquid flow in porous media states:

$$Q = \frac{kA\Delta P}{\mu L} \qquad k = \frac{Q\mu L}{A\Delta P} \qquad [1]$$

where Q represents milliliters of liquid of viscosity μ centipoises passed per second through a porous medium of permeability k darcys and cross-sectional area A sq. cm. under a pressure gradient $\Delta P/L$ atmospheres per centimeter, the flow being understood to be laminar or viscous, not turbulent. This equation defines the darcy. For the case of radial flow in a uniform sand, such as usually exists in the neighborhood of a well in an oil or gas sand, Darcy's law becomes:[2]

$$Q = \frac{2\pi kh\Delta P}{\mu \log_e r_e/r_w} = \frac{2\pi kh(P_e - P_w)}{\mu \log_e r_e/r_w} \qquad [2]$$

Here h is the net sand thickness in feet, P_e and P_w are pressures at the drainage radius[4] and well radius, and r_e and r_w are these radii, respectively. The productivity index[3] is defined as the barrels of liquid produced per day per pound per square inch mean pressure differential between reservoir and well bore, and is thus:

$$PI = \frac{Q}{P_e - P_w} = \frac{2\pi kh}{\mu \log_e r_e/r_w} \qquad [3]$$

By further definition, the specific productivity index is:

$$SPI = \frac{Q}{h(P_e - P_w)} = \frac{2\pi k}{\mu \log_e r_e/r_w} \qquad [4]$$

or in terms of practical units, and allowing for shrinkage:

$$SPI = \frac{3.073k}{\mu FVF \log_{10} r_e/r_w} \qquad [5]$$

Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1871 in Petroleum Technology, May 1945.

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[1] References are at the end of the paper.

Here *SPI* is in barrels of tank liquid per day per pound per square inch pressure differential between reservoir and well bore per foot of net sand, and *FVF* is the formation volume factor of the tank liquid.

The formula in Eq. 5 states that for a given liquid of known and constant formation viscosity and volume factor, and for a well draining a given area, the *SPI* of that well should be directly proportional to the sand permeability. Mid-Continent experience seems frequently to agree with this statement.[5–11] California experience is definitely not in agreement[2,12,13] with any such simple statement.

Deviations from Darcy's Law

There are many reasons why the rate of influx of fluids into the bore of a well may be smaller than predicted by Darcy's law. The permeability of a porous medium is defined as a property of the rock structure, to be measured by the controlled flow of a fluid, which neither in any way modifies the rock structure nor has any interaction with it. Clean, dry air is thought to have little or no interaction with the rock structure, and to cause no permanent change in the permeability. However, in the reservoir the porous medium is not saturated with clean, dry air, but with interstitial water, oil, and gas, either in solution or free. The laboratory process of eliminating the reservoir fluids may drastically change the rock structure, as will be shown below.

Other factors that tend to cause the rate of fluid flow into a well to fall below the Darcy law prediction are: the heterogeneity of fluids in the flowing stream, the heterogeneity of the formation itself, and the several factors of the well completion, such as mud particles in the pores of the sand walls, partially plugged perforations, etc., which cause added resistance to fluid flow. Of these factors, the one that is most susceptible to laboratory investigation, and which has been studied most thoroughly, is the heterogeneity of fluids in the flowing stream. Several authors have capably dealt with the effect one fluid in a sand may have on the flow of a second fluid, or the effect of two fluids on the flow of a third.[14–22] The permeability to one fluid in the presence of others is called "effective permeability," and its ratio to the permeability is called "relative permeability." These definitions and references are given here to permit anyone interested in this phase of reservoir flow to look elsewhere, as the present discussion will be limited to the effect on permeability of the interaction of fluids and the solid structure.

Reservoir Permeability

The undisturbed porous medium has three different relative permeabilities, to gas, oil, and water, depending mainly on the saturation by each of these fluids, but partly on the distribution of this saturation. The basic, specific permeability to a single fluid, to which these relative permeabilities are referred, is the chief subject of this discussion. The many hundred thousand sand permeabilities that have been measured with air are supposed to be representative of this basic property. That these figures often badly misrepresent the facts will be amply shown later. The reason for this disparity between air permeability and reservoir permeability is that the sand structure itself is seriously modified in many cases by the processes of cleaning and drying preparatory to measuring air permeability.

In the reservoir, the sand generally is intimately surrounded and wet by interstitial water. The nature and properties of every rock particle and of the structure as a whole are conditioned by this fact. Any hydratable material is in a condition of hydration that depends on the compo-

sition of this water, and somewhat on temperature and pressure. There may be some degree of dependence, at least of the surface characteristics of the rock particles, on the types of oil present. When both interstitial water and oil are removed, what reason is there to believe that the rock structure suffers no change in effective size, distribution or orientation of its component particles? We know that in hydratable clays the discrete particles swell because of adsorption of water around them; also, some of the particles may be broken apart by water intrusion between the crystalline platelets, so that two or more discrete particles may result from hydration of a single particle.

Thus, when a clay particle, partially hydrated in the interstitial water, is subjected to any change in that water, corresponding changes in its state of hydration may result. There is the distinct possibility that a part or several parts of it may be loosened and migrate to a point where they may clog a constriction in one of the capillary channels. Conversely, clay particles so disturbed and redistributed, possibly causing drastic changes in observed permeability, may easily be again redistributed on cleaning in hot solvent, followed by oven drying. Particles that originally had adhered to sand grains, and which changes in hydration had caused to swell, break down and migrate, may remain loose and mobile after oven drying, or they may attach themselves to sand grains in different positions from those originally occupied. Thus it is evident that several changes drastically affecting permeability may occur between the undisturbed reservoir and the air permeameter in the laboratory.

Permeability, by definition, must be measured by a single-phase fluid. Reservoir permeability, most nearly approximated by a salt-water flow test, is very difficult to measure, since oil cores received at the surface contain three phases, gas, oil and water; and the two phases that must be removed to allow the closest approximation to reservoir permeability, namely oil and gas, cannot be removed by flowing any other medium, such as a solvent, through the core, followed by removal of the solvent, without almost certainly causing some of the changes described above. Disregarding the economic aspect of core analysis, the attempt to remove reservoir oil and gas by continued flow of interstitial water, even to a concentration at which they would have little effect on the single-phase water permeability, is an attempt to do the impossible. Also, it must be remembered that the reservoir rock during coring is to some extent invaded with mud filtrate, so that it becomes impossible to obtain a sample that exactly represents the undisturbed state. Consequently, the measurement of reservoir permeability must be a compromise, and the best approximation will be obtained by choosing the lesser of the several evils. One approach to the measurement of the reservoir permeability of a consolidated sand is as follows:

The fresh core sample is shaped, extracted with appropriate solvent, and then dried at 225°F. The sample is set in the center of a (2 by 4-in.) thick-walled Pyrex tube by means of a mixture of green optical pitch and (100 sec.) pale oil of naphthenic base in the proportion of about 30 ml. oil per pound fresh pitch. After the air permeability has been measured, the core is protected from disintegration under the influence of water by packing each end of the tube with sand washed free of hydratable material. Relative to the core solids, the sand is coarse, and it is of uniform grain size. The sand is held firmly in place with metal screens backed by a disk of sponge rubber. The tube is mounted in a rack and the sponge-rubber disks are compressed against the protecting sand by forcing rubber stoppers into the

ends of the tube. The air permeability is then measured again to determine any change in the apparent permeability of the core that may have occurred during the process of protecting the sample.

The tube is alternately evacuated and flushed with carbon dioxide before the water is introduced. If two or more types of water are to be used, the most saline is introduced first, as it is expected to produce the least hydration of any clay (or similar material) present. To permit an opportunity for hydration to take place, the permeability measurement is delayed for a time. In routine core analysis, an interval of 2 hr. is allowed to elapse. As repeated tests indicate that a fair approximation is obtained, this interval is considered a good compromise between accuracy and speed. No permeability measurement demands extreme accuracy, since the taking of a given sample a fraction of an inch higher or lower in the hole may radically change the numerical value. Core work demands a statistical number of fairly accurate measurements, rather than a few extremely accurate tests.

After the salt-water permeability has been measured, fresh water is introduced as follows: The appropriate stopper is removed, and the sand protecting the inflow side of the core is flushed well with distilled water. The stopper is replaced, and distilled water (equivalent to 1 or 2 pore volumes) is forced through the sample. As rather extensive hydration may take place, 20 to 24 hr. usually is allowed to elapse before the fresh water permeability is measured. Comparisons between air and liquid permeabilities are more readily obtained in loose sands because serious disintegration of a sand pack under the influence of water is uncommon, the spring compressing the pack tending to offset any moderate loss of sand.

In routine core analysis, the water used in the early work was distilled water containing 1650 grains of sodium chloride per gallon, making a solution of 1000 gr. per gal. chloride ion. Soon, this was replaced by actual formation water from the same zone from which the cores had been taken. However, it was found exceedingly difficult to use formation waters without clogging the cores with solid particles. An exacting procedure had to be followed rigorously from the time the water was sampled at the well until the last time the water was used for a permeability measurement. Otherwise, suspensions of calcium carbonate or ferric hydroxide continued to form throughout the liquid, caused by the evolution of carbon dioxide from bicarbonates, or by the oxidation of ferrous salts by air. Accordingly, it was decided to use distilled water containing an amount of salt approximating the total ion concentration of the interstitial water. A series of standard solutions of sodium chloride in distilled water was made up, starting with 2000 gr. per gal. chloride ion, and decreasing by a factor of ½ down to and including 31 gr. per gal. The standard solution most closely approximating the salinity of the formation water is used for cores from any given formation. When the analysis of the formation water is unknown, the solution containing 1000 gr. per gal. chloride ion is used. Tabulated values of salt-water permeability were thus obtained with various waters, but results are not radically changed by these variations.

All permeabilities are measured at room temperature, and air is not excluded from the distilled water or from the sodium chloride solutions except during the saturation process. Tests are now under way to determine the advisability of incorporating germicides in the standard solutions.

Results

The following data are tabulated to show the effects of saline and fresh water on the permeability of core samples from various reservoirs. The routine work to date

has covered more than 1200 samples from 94 wells penetrating 42 pools in 23 fields, mostly in California.

TABLE 1.—*Difference between Air and Salt-water Permeability*

Permeability, Md., to			Permeability Ratio:
Air	Salt Water	Fresh Water	Air / Salt Water
129	0.0	0.0	∞
41	0.0	0.0	∞
22	0.0	0.0	∞
3.8	0.0	0.0	∞
1,490	0.45	0.0	3,300
46	0.2	0.1	230
112	0.8	0.5	140
105	0.9	0.9	117
159	1.6	0.4	99
5.5	0.07	0.07	79
310	5.0	1.5	62
18	0.39	0.25	46
104	3.7	0.1	28
1,270	66	[a]	19
190	12	7.2	16
71	5.4	0.0	13
2,560	216	0.0	12
52	5.3	2.1	10
624	85	25	7.4
53,400	9,260	6,530	5.8
37	7.2	1.9	5.1
455	110	105	4.1
82	23	2.8	3.6
2,040	668	5.7	3.1
1,590	565	2.6	2.8
4,400	1,810	199	2.4
481	228	11	2.1
1,330	705	71	1.89
3,540	2,093	2.4	1.69
35	22	2.8	1.59
34,800	23,600	9.9	1.47
440	302	0.0	1.45
6,890	5,510	330	1.25
18,800	15,800	15,100	1.19
565	505	210	1.12
81	76	66	1.06
11,350	10,930	8,950	1.04
2,060	2,020	1,630	1.02
420	415	101	1.01
31	31	12	1.00

[a] Sample disintegrated in fresh water.

Table 1 shows data on air permeabilities vs. salt-water permeabilities picked to indicate the range from great difference to little difference. It is to be noted that the ratio of air to salt-water permeability varies from over 3000 to about 1.0. Scores of samples show ratios greater than 10.

Table 2 shows data on fresh-water vs. salt-water permeability. The latter is used as the standard value to which both air and fresh-water values are compared, as the salt-water permeability is intended to be a close approximation to the true reservoir value, while the others have special uses but are not basic. In Table 2, it will be noted that the ratio of fresh-water

TABLE 2.—*Difference between Salt-water and Fresh-water Permeability*

Permeability, Md., to			Permeability Ratio:
Air	Salt Water	Fresh Water	Fresh Water / Salt Water
18,500	3,050	0.0	0
5,130	845	0.0	0
440	302	0.0	0
705	147	0.0	0
434	39	0.0	0
220	13	0.0	0
22	6.7	0.0	0
28	3.3	0.0	0
5.8	0.2	0.0	0
17,400	5,550	0.1	0.000018
6,100	2,040	0.1	0.000049
2,460	617	0.1	0.000162
34,800	23,600	9.9	0.00042
3,760	3,800	3.3	0.00087
22,800	13,600	19.5	0.00143
3,100	1,590	4.4	0.00277
26,800	15,400	62	0.0040
69	6.1	0.06	0.0098
1,770	1,115	18	0.0162
104	3.7	0.1	0.027
344	66	3.5	0.053
20,410	14,600	1,080	0.074
1,200	300	30	0.100
4,400	1,810	199	0.110
1,020	114	20	0.175
37,500	13,550	3,305	0.242
926	426	140	0.328
395	210	84	0.400
26	2.7	1.3	0.481
705	655	430	0.656
2,610	2,810	2,000	0.711
115	116	95	0.818
2,380	1,610	1,380	0.857
5,270	2,990	2,830	0.947
455	110	105	0.955
18,800	15,800	15,100	0.955
108	78	77	0.988
1,690	1,690	1,670	0.988
645	573	568	0.991
105	0.9	0.9	1.00
52	20	20	1.00

to salt-water permeability may range from practically zero to about 1.0.

Frequently it is true that where the ratio of air to salt water is large, the ratio of fresh water to salt water will be a small number. In other words, where the agent responsible for the decrease in permeability as the fluid is changed from air to salt water to fresh water causes a large decline in the first change of fluids, it will also cause a large decline in the second change.

Table 3 is a general tabulation of all routine tests to date, wherever enough

TABLE 3.—*Summary of Water-permeability Data*

Field	Zone	Number of Wells	Number of Tests	Permeability, Md., to			Permeability Ratios		
				Air	Salt Water	Fresh Water	Air / Salt Water, Per Cent	Fresh Water / Salt Water, Average, Per Cent	Fresh Water / Salt Water, Range, Per Cent
A	1	3	20	53[a]	17	1.1	310	6.5	2 – 12
				384[a]	212	185	139	87	68 – 94
B	2	2	109	289	211	4.3	137	5.0	2.8 – 8.2
				905	603	231	150	38	5 –100
B	3	3	71	1,965	975	8.3	200	0.85	0.7 – 1.0
				1,207	637	110	189	17	4 – 27
B	4	2	13	1,580	1,040	144	152	14	1.3 – 19
				1,100	820	516	134	63	48 –100
C	5	1	8	450	286	233	157	81	54 –100
C	6	1	8	34	17	12	200	71	55 – 92
C	7	1	1	18	0.39	0.25	4,600	64	64
D	8	3	30	982	304	1.2	323	0.40	0.2 – 0.7
				513	139	49	370	35	9 – 75
E	9	2	11	1,233	134	0.0	920	0.0	0
				13,350	4,610	418	290	9.0	0.0 – 22
E	10	2	5	8,670	5,070	15	171	3.0	0.5 – 21
				1,590	1,280	429	124	34	34
E	11	2	26	2,280	550	0.05	415	0.01	0.0 – 0.02
				2,450	1,115	17.7	220	1.55	0.5 – 10
E	12	1	5	3,240	2,035	1,245	159	61	2 – 91
F	13	1	6	136	104	86	131	82	69 –100
G	14	1	2	1,925	124	73	155	59	58 – 60
G	15	1	5	221	18.5	12.5	1,600	68	56 –100
H	16	1	8	161	22	13	732	59	30 –100
H	17	1	4	1,908	334	209	572	63	44 – 94
I	18	2	12	50	2.7	0.8	1,850	30	27 – 80
				864	375	198	230	53	24 – 73
I	19	2	54	94	27	5.8	350	21	1.3 – 90
				553	350	218	158	62	37 –100
	20	10	294	6,444	1,628	0.0	395	0.0	0
				4,890	3,280	2,380	149	88	35 –100
J	21	1	5	1,356	443	2.4	306	0.5	0.0 – 3.2
K	22	1	5	3,750	2,760	628	136	23	7 – 63
L	23	5	42	1,830	542	225	338	41	5.3 – 70
				2,685	1,645	1,540	163	94	77 –100
L	24	1	25	2,100	1,383	479	152	35	2 – 76
L	25	2	52	2,100	1,990	1,500	106	75	49 –100
				3,100	3,000	2,800	103	93	76 –100
L	26	1	13	3,460	1,580	2.9	220	0.2	0.006– 1.1
M	27	1	15	4,410	1,549	1,049	285	68	24 – 91
N	28	1	12	45	13	6.8	345	52	0.0 – 94
O	29	4	29	52	10	0.004	520	0.04	0.0 – 1.5
				339	108	23	315	21	9 – 97
P	30	1	2	801	2.1	0.8	38,000	38	0.0 – 56
Q	31	4	15	607	378	1.5	160	0.4	0.2 – 0.5
				108	47	33	230	71	30 – 75
Q	32	1	5	600	21	4.3	2,850	20	2.9 – 56
R	33	3	78	3,190	1,630	869	195	53	35 – 63
S	34	16	78	4,630	1,840	5.0	250	0.3	0.0 – 2.0
				2,674	1,343	1,318	198	98	88 –100
T	35	5	67	2,030	1,495	188	136	13	1.5 – 95
				2,770	1,920	1,040	144	54	24 – 70
T	36	1	3	402	84	16	480	19	10 – 24
T	37	3	22	216	54	39	400	72	24 –100
				3,010	2,450	1,920	123	78	73 – 91
U	38	6	20	275	180	71	153	39	39
				54	39	32	138	82	82
U	39	2	12	4.3	3.2	1.4	134	43	30 – 82
				18	10	8	180	80	56 – 82
U	40	2	14	48	5.4	2.1	890	39	22 – 60
				28	13	8.9	215	68	31 –100
U	41	2	9	86	3.8	1.8	2,260	47	36 – 52
				32	17	16	188	94	78 –100
V	42	1	13	70	68	44	103	65	44 –100
W	43	1	5	9	6.1	1.9	148	31	6 – 58

[a] First line of data for any zone is typical of greatest fresh-water effect for an entire well; second line of data typifies least effect for same zone, for a different well.

TABLE 4.—*Typical Well Data*

Well A, Consolidated				Well B, Loose			
Permeability, Md., to			Fresh-water Index,[a] Per Cent	Permeability, Md., to			Fresh-water Index,[a] Per Cent
Air	Salt Water	Fresh Water		Air	Salt Water	Fresh Water	
285	62	2.2	3.6	660	354	17	4.8
481	228	11	4.8	655	340	26	7.6
123	82	5.9	7.2	680	342	38	11
113	43	1.9	4.4	296	198	40	20
61	6.8	1.2	18	374	279	63	23
36	0.4	0.1	25	1,030	485	22	4.5
159	1.6	0.4	25	192	98	21	22
72	2.3	0.7	30	211[b]	65	48	74
310	5.0	1.5	30	625[b]	242	170	70
328	57	51	90	420	216	22	10
42	23	6.4	28	236	112	17	15
24	24	16	67	260	129	56	43
51	16	5.6	35	322	168	29	17
42	29	4.1	14	330	58	8	14
35	17	2.7	16	560	240	56	23
41	15	5.1	34	214	63	7	11
22	14	4.0	29	715	437	15	3.4
46	16	5.7	35	470	305	27	8.8
92	89	12	13	535	267	11	4.1
178	40	6.4	16	405	217	14	6.4
20	12	2.9	24	325	186	14	7.5
14	5.9	1.8	31	270	101	34	34
9.8	6.1	2.8	46	470	240	59	25
25	13	3.5	27				
14	9.9	3.5	35				
36	22	3.5	16				
104	6.7	2.1	31				
88	11	2.3	21				
438	360	4.9	1.4				

Well C, Consolidated				Well D, Loose			
Permeability, Md., to			Fresh-water Index,[a] Per Cent	Permeability, Md., to			Fresh-water Index,[a] Per Cent
Air	Salt Water	Fresh Water		Air	Salt Water	Fresh Water	
368	41	27	66	350	165	115	70
445	70	62	89	455	110	105	95
221	28	8.3	29	625	85	25	29
302	58	54	93	975	540	36	6.7
73	2.5	0.8	32	1,550	1,140	200	18
33	4.5	5.0	111	565	505	210	42
266	69	50	72	6,890	5,510	330	6.0
616	230	168	73	5,000	2,980	155	5.2
262	25	35	140	875	495	28	5.7
191	57	50	88	420	415	101	24
283	41	42	102	4,250	2,510	34	1.4
130	34	33	97	3,510	2,460	84	3.4
304	21	15	72	3,140	2,100	40	1.9
66	32	20	63	3,120	1,950	150	7.7
61	17	15	89	1,120	540	135	25
10	3	4	133	1,870	1,090	355	33
52	20	20	100	3,810	3,410	1,170	34
50	22	5.4	25	1,530	875	125	14
117	37	26	70				
230	134	70	52				
14	9	5	55				

[a] Ratio of fresh-water to salt-water permeability, per cent.
[b] Consolidated samples.

TABLE 5.—*Permeability Profiles for Laminar and Massive Sediments*

Laminar Sediment				Massive Sediment			
Permeability, Md., to			Fresh-water Index, Per Cent	Permeability, Md., to			Fresh-water Index, Per Cent
Air	Salt Water	Fresh Water		Air	Salt Water	Fresh Water	
525	274	98	36	6,380	1,885	1,330	71
440	302	0.0	0.0	7,020	2,340	1,580	68
335	320	28	8.8	3,650	1,010	746	74
217	133	35	26	5,720	1,480	864	58
180	182	84	46	9,650	1,780	1,360	76
115	116	95	82	5,100	1,630	886	54
180	144	89	62	4,800	1,610	1,063	66
105	0.9	0.9	100	4,500	1,200	614	51
61	14	1.5	10.7	3,680	1,800	1,080	60
82	23	2.8	12.2	8,920	3,490	2,840	81
65	34	7.7	23	11,900	5,330	4,330	81
220	151	31	20	6,190	4,880	3,920	80
8.8	5.3	4.3	81	12,400	4,380	3,490	80
9.5	6.3	5.7	91	10,400	4,160	3,180	77
14	10	4.1	41	7,970	2,340	1,790	77
14	2.2	1.8	82				
5.9	4.9	2.2	45				
19	12	4.7	39				
28	18	6.6	37				
153	80	6.6	8.3				

samples were tested to have any sort of statistical value. This is the only tabulation containing data on wells outside of California. These are arranged by fields and zones, so a study may be made of the uniformity of water-permeability ratios in individual zones. In general, no zone or field has regularly high or low ratios, so that there would appear to be little chance to "calibrate" any zone or pool or field with cores from a few wells, obtaining ratios that could then be used to determine reservoir permeability from air permeabilities in other wells in the same zone or pool. This is an unfortunate but definite conclusion.

TABLE 6.—*Contact between Clean Sand and Hydratable Sand*
15 SAMPLES IN 23 FEET

Permeability, Md., to			Fresh-water Index, Per Cent
Air	Salt Water	Fresh Water	
3,970	635	217	34
4,790	2,020	1,650	82
4,490	965	313	32
2,640	734	520	71
4,810	2,670	2,340	88
5,280	2,400	1,980	83
5,730	2,270	1,400	62
10,900	4,660	1,740	37
6,600	3,250	2,680	82
5,270	2,990	2,830	95
5,650	2,210	7.4	0.33
7,760	2,640	10.0	0.38
2,430	1,190	2.6	0.22
4,070	1,290	7.5	0.58
2,260	1,070	90	8.4

Table 4 shows typical sequence of core-analysis results for four wells, two in consolidated and two in loose sand, indicating that there is nothing predictable about water-permeability ratios. They are almost certainly measures of the lithologic character of the sediment, thus might be expected to vary irregularly in a highly laminar sediment and to be more nearly uniform in a massive sediment, as shown in Table 5.

Table 6 shows a contact between a massive clean sand and a laminar sediment containing hydratable material. There are 15 samples in 23 ft. represented in this tabulation, no two adjacent samples being more than 2 ft. or less than 1 ft. apart. The purpose of this tabulation is to show that cases do occur where neither air nor salt-water permeability will suggest the presence of hydratable content of the sand, but fresh water brings out this lithologic character with sharp contrast.

TABLE 7.—*Permeabilities of Sands of the Four Permeability Ratio Types*

$\frac{\text{Air}}{\text{Salt Water}}$ Small; $\frac{\text{Fresh Water}}{\text{Salt Water}} \sim 1$

Permeability, Md., to			Permeability Ratios, Per Cent	
Air	Salt Water	Fresh Water	Air / Salt Water	Fresh Water / Salt Water
4,260	4,360	4,260	98	98
3,880	2,550	2,570	152	101
4,180	3,580	3,380	117	94
4,360	2,660	2,800	164	105
3,700	2,840	2,730	130	96
3,490	2,260	2,320	154	103
3,210	2,170	2,210	148	102
3,470	2,500	2,410	139	96
3,840	4,620	4,100	83	89
1,740	1,550	1,410	112	91
2,170	2,470	2,180	88	88
2,840	1,730	1,600	164	93
Av.......			129	96

$\frac{\text{Air}}{\text{Salt Water}}$ Small; $\frac{\text{Fresh Water}}{\text{Salt Water}} \sim 0$

Permeability, Md., to			Permeability Ratios, Per Cent	
Air	Salt Water	Fresh Water	Air / Salt Water	Fresh Water / Salt Water
194	59	4.7	329	8.0
173	74	0.8	234	1.1
89	31	1.3	288	4.2
69	31	0.4	223	1.3
93	71	3.0	131	4.2
142	76	1.5	187	2.0
175	153	3.9	114	2.5
103	54	4.0	191	7.4
60	42	4.1	143	9.7
Av...			204	4.5

$\frac{\text{Air}}{\text{Salt Water}}$ Large; $\frac{\text{Fresh Water}}{\text{Salt Water}} \sim 1$

Air	Salt Water	Fresh Water	Air / Salt Water	Fresh Water / Salt Water
105	17	12	618	71
50	3.8	4.9	1,320	129
397	6.9	5.6	575	81
82	23	13	357	57
472	42	27	1,120	64
Av......			798	80

$\frac{\text{Air}}{\text{Salt Water}}$ Large; $\frac{\text{Fresh Water}}{\text{Salt Water}} \sim 0$

Air	Salt Water	Fresh Water	Air / Salt Water	Fresh Water / Salt Water
66	6.6	0.0	1,000	0
54	7.1	0.3	760	4.2
45	5.0	0.0	900	0
105	16.1	0.0	653	0
42	6.3	0.0	667	0
			795	0.8

TABLE 8.—*Permeability (Millidarcys) vs. Decreasing Salinity of Water (Grains per Gallon Chloride Ion as Shown*[a]*)*

Field	Zone	K_a	K_{1000}	K_{500}	K_{300}	K_{200}	K_{100}	K_w
S	34	4,080	1,445	1,380	1,290	1,190	885	17.2
S	34	24,800	11,800	10,600	10,000	9,000	7,400	147
S	34	40,100	23,000	18,600	15,300	13,800	8,200	270
S	34	39,700	20,400	17,600	17,300	17,100	14,300	1,680
S	34	12,000	5,450	4,550	4,600	4,510	3,280	167
S	34	4,850	1,910	1,430	925	736	326	5.0
S	34	22,800	13,600	6,150	4,010	3,490	1,970	19.5
S	34	34,800	23,600	7,800	5,460	5,220	3,860	9.9
S	34	27,000	21,000	15,400	13,100	12,900	10,900	1,030
S	34	12,500	4,750	2,800	1,680	973	157	2.4
S	34	13,600	5,160	4,640	4,200	4,150	2,790	197
S	34	7,640	1,788	1,840	2,010	2,540	2,020	119
S	34	11,100	4,250	2,520	1,500	866	180	6.2
S	34	6,500	2,380	2,080	1,585	1,230	794	4.1
T	36	2,630	2,180	2,140	2,080	2,150	2,010	1,960
T	36	3,340	2,820	2,730	2,700	2,690	2,490	2,460
T	36	2,640	2,040	1,920	1,860	1,860	1,680	1,550
T	36	3,360	2,500	2,400	2,340	2,340	2,280	2,060
T	36	4,020	3,180	2,900	2,860	2,820	2,650	2,460
T	36	3,090	2,080	1,900	1,750	1,630	1,490	1,040

[a] For example: K_a means permeability to air,
K_{500} means permeability to 500 gr. per gal. Cl solution,
K_w means permeability to fresh water.

Table 7 shows examples of all four possible sand types, as regards permeability ratios. Section A gives data from a sand only slightly affected by either salt water or fresh water. Section B gives data from a sand greatly affected by salt water but not further greatly affected by fresh water. (This type is rather uncommon.) Section C shows data on a sand not much affected by salt water but greatly affected by fresh water (a fairly common type.) Section D shows data from a sand greatly affected first by salt water and then further by fresh water.

Table 8 shows the effect on water permeability of successive decreases in salinity of the water. No attempt is made to show the many possible permeability ratios, but the interested reader can analyze the data for his particular purposes. He will find that some sand samples show rapid permeability decline even in the higher salinity ranges, whereas other samples hold high water permeability well down into low salinities. The variety of behavior noted in only two pools or zones indicated that the amount, distribution, and swelling characteristics of the clay or other affected solids in the sand must vary over a considerable range in the many reservoirs. This type of information could be of greater value in determining the nature of the hydratable material in any given pool than the simpler study of salt and fresh-water permeabilities alone. The obvious drawback is that the amount of laboratory work is many times as great as for the simpler study.

There is a tendency for a sand interval showing a nonuniform air-permeability profile to show a still less uniform water-permeability profile. It is believed that some of the low air-permeability values may be caused by a larger than normal amount of fine, hydratable material. Consequently, the water permeability of such samples will show a greater decrease from the air-permeability value than for clean samples, and the resultant water-permeability profile will be more ragged than is the profile of air-permeability values. This deserves further study. It is mentioned here more to arouse discussion than to state a proved fact.

Applications

This type of information affects many drilling and production operations. The present discussion was planned to bring out the nature and magnitude of the effects rather than to suggest field procedures to take advantage of them.

One application of interest is the improvement in the empirical relation between specific productivity index and permeability. As shown statistically in a recent paper,[3] the deviations between the empirical and the theoretical relation are large and somewhat variable. It is the authors' belief that a large part of both the deviation and its variability may be directly due to the differences between air and reservoir permeability. The average of the air/salt-water permeability ratio for the entire 1200 plus cores does not show a large enough value to account for the entire deviation from the theoretical relation, so it might be said that the distinction between air and salt-water permeability is not of major importance. However, for any given well, the ratio may be of great importance, as one will find in looking through Table 3. Certainly, for specific zones in certain wells, the magnitude of this ratio supersedes in importance all other considerations as regards the zone productivity. Cases have arisen frequently where a good oil zone appears interrupted by permeable wet sands without benefit of shale strata to separate the oil from the water. This is the picture obtained from air permeabilities; tests with water show the wet streaks to be almost entirely impervious, and thus of little consequence to well completion. Such good fortune cannot always be counted on, and the mere

uncertainty of interpretation seems to the authors sufficient reason to spend the extra effort required for water permeabilities.

One beneficial step in interpretation of core analysis would be the development of an empirical relation between specific productivity index and salt-water permeability. The delay in getting such a correlation worked out on the basis of water permeabilities is that, to the authors' knowledge, only one operator is making such measurements in routine quantity. The previous empirical relation was the result of data from many operators. The data thus had the advantages of being more completely representative of California oil reservoirs and greater in number than data any one operator can collect in a reasonable period of time. The writers would welcome any similar measurements by other operators, which could ultimately be the basis for a new empirical relation between reservoir permeability and specific productivity index.

Future Work

There are two objectives of this type of work besides merely obtaining more representative data in larger quantity. One is the improvement of the laboratory technique to permit quicker results and greater reliability on the friable samples and those which decompose readily in water. Several improvements have already been made since this work was initiated, but there is certainly room for further improvement.

The other aspect is that of interpretation. Results observed to date appear to be satisfactorily explained by the presence in the sand of hydratable materials, such as clays. Further research is warranted, as for instance with petrographic analysis, to prove or disprove this hypothesis. The purpose of the present paper will have been served, however, if those using sand-permeability measurements realize the inadequacy of measurements made with air.

Acknowledgments

Thanks are gratefully expressed to the several chemists and laboratory assistants who made the measurements here quoted and aided greatly in developing necessary laboratory technique. The authors thank Mr. H. N. Marsh for continued encouragement, and the General Petroleum Corporation for permission to publish these data.

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DISCUSSION

W. F. Cerini.*—Johnston and Beeson have given impetus to the study of one-phase fluid flow employing a liquid that is common to oil reservoirs. The premise that salt-water permeability is probably closer to the true reservoir permeability than is the measurement with air appears to be logical. The lack of proportionality between the specific productivity index and the permeability of California sands for a given liquid of known and constant formation viscosity and volume factor, may be at least partially attributed to the use of air permeability results.

Salt-water permeability tests of cores have been studied for some time by the Union Oil Co. The wide permeability range made possible by obtaining cores from many localities by the authors has not been duplicated, but results appear to indicate that the variation between air and formation-water permeability may be less marked than reported. It is to be emphasized that the water used should be free of suspended matter, sterile, and that a glass system be employed. Possibly some of the plugging action attributed by the authors to hydration of clays may have been partly due to organic material present.

It is believed that the study of formation-water permeability of cores constitutes an important phase of core analysis. An intensive study of hydration effects of salt and fresh water, as well as fresh-water permeabilities appears to be requisite. Emphasis should be placed also on the possibility of obtaining uncontaminated core samples at reservoir conditions to enhance the study of multiple-phase fluid flow for the purpose of relative permeability and water-flooding determinations.

* Union Oil Company of California, Compton, California.

N. Johnston and C. M. Beeson (authors' reply).—Subsequent to presentation of the paper, data have been obtained concerning the possible effect of bacteria and other plugging agents upon the measurement of liquid permeability. Unfiltered and untreated solutions of distilled water containing 0, 500, 1000, and 2000 grains of chloride ion per gallon from U.S.P. grade sodium chloride were aged for periods up to 6 months and then forced through an all-glass system of sintered glass filters with permeabilities varying from 50 to 500 md. From 150 to 250 ml. of each solution was passed through each square centimeter of each filter. This is considerably more than is forced through a core sample during measurement of liquid permeability in routine core analysis.

A plot of volume collected versus time gave essentially straight lines. Very few points deviated from the approximate line by more than 3 per cent and none by more than 12 per cent. For this reason, it was concluded that unfiltered solutions of U.S.P. grade sodium chloride and distilled water containing no germicide were satisfactory for the routine tests described in the paper. On the other hand, extended flow tests, and especially those involving the flow of several liters per square centimeter through sintered glass filters, have shown that extreme care must be taken to prevent plugging by bacteria or precipitates under the more rigorous conditions.

H. G. Botset.*—This paper represents a great deal of excellent experimental work and the authors have made a real contribution to our knowledge of porous flow phenomena. Experiments performed on California producing sands in our own laboratory have completely confirmed the results obtained by the authors. Not all sands exhibit these properties, of course, but it is very important from a production standpoint to know the reaction of the sand in each reservoir to water flow, and this information can probably be obtained

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only by experimental measurements of the type described in this paper.

D. S. Nutter.*—This paper is of particular interest in view of the widespread current use of permeabilities as measured with air. The authors are to be commended both for putting permeability measurements with water on a routine basis and thus obtaining a very significant number of results, and for including in their paper the actual data rather than only the conclusions drawn therefrom. In bringing to the attention of the industry the considerable differences that exist between the actual air and water permeabilities of oil-field core samples, the authors have performed a distinct service.

The desirability of a correlation between specific productivity index and salt-water permeability has been pointed out. I should like to inquire whether from the measurements presented it has been possible to derive a tentative relation of this sort, and whether it has been observed that for particular wells with comparable air permeabilities but with different specific productivity indexes the differences between the air and water permeabilities are of the proper direction and magnitude to help explain the difference in the productivities of those wells.

N. Johnston and C. M. Beeson.—As yet there has been little opportunity to correlate specific productivity index with salt-water permeability. Such an undertaking could be carried to completion much more quickly with the help of others, and it is hoped that water permeability will become more generally measured throughout the industry.

* Shell Oil Company, Inc., Long Beach, California.

Flow into Slotted Liners and an Application of the Theory to Core Analysis

By C. R. Dodson,* Member A.I.M.E., and W. T. Cardwell, Jr.*

(Los Angeles Meeting, Octob 1943)

This paper presents the results of a theoretical and experimental study of the effect of preperforated liners on well productivity. The analysis concerns the rectangular type of slot,

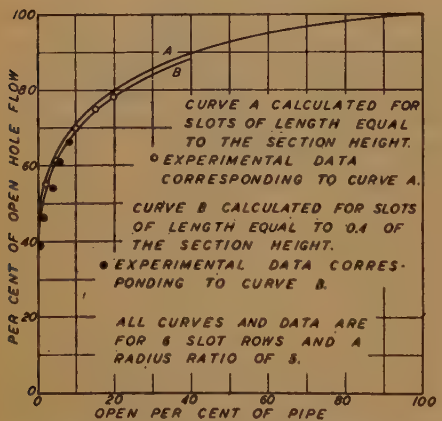

Fig. 1.—Percentage of open-hole flow that may pass into a slotted liner.

either machine or torch cut, which is common in California.

Muskat[18] treated this problem recently in a mathematical analysis of the flow of oil or gas from natural reservoirs into both gun-perforated and slotted liners. This paper presents additional and simplified analytical considerations and conclusions for the slotted liner, the solutions being applicable in the laboratory as well as in the field.

An application of the analytical methods to permeability measurements on mounted core samples is given, to show the effects of sealing wax or other obstructions on the end faces of the cores.

Manuscript received at the office of the Institute Nov. 18, 1943. Issued as T.P. 1724 in Petroleum Technology, March 1944.

* Standard Oil Company of California, La Habra, California.

Results

Fig. 1 compares the results of some theoretical calculations with the results of electrical analogy experiments performed in the Standard Oil Company of California's Production Technology Laboratory at La Habra, California.

Fig. 1 indicates that the flux into short, "three-dimensional slots" of the relative dimensions encountered in practice is approximately equal to that into full-length, "two-dimensional slots" having the same open fraction of pipe. (The same numbers of slot rows, and the same radius ratio are also implied.) It can be seen from physical considerations that the closeness of this approximation must improve as the ratio of the external radius to the internal radius increases. Therefore, it is possible to calculate the flow into a slotted liner using a simple modification of the Darcy equation:

$$Q = \frac{2\pi kh(p_e - p_w)}{\mu\left(\ln\frac{r_e}{r_w} + \frac{2}{N}\ln\frac{2}{\pi\Omega}\right)} \qquad [28]$$

where N is the number of slot rows and Ω is the open fraction of the pipe.

Fig. 2 shows the results of calculations using Eq. 28.

The most remarkable features of Fig. 2 are the high flux values for very small open fractions of pipe. For instance, with six slot rows and a radius ratio of 500, 74 per cent of the open-hole flux may be obtained with only 0.1 per cent of pipe open.

Fig. 2 shows that for a given open fraction of pipe, the flux is greater, the greater

the number of slot rows. It is interesting to consider this conclusion in conjunction with Fig. 5 of Muskat,[1] which pertains to gun perforations. Muskat's Fig. 5 shows that a given number of ⅛-in. perforations will give more flux than the necessary number of ¼-in. holes to give the same total open area.

Fig. 2 shows also that the greater the radius ratio, the more closely the flux into a slotted liner will approximate the open-hole flux. It is apparent from physical considerations that if the radius ratio were infinite the liner design would have no effect on productivity.

The results of Fig. 2 do not strictly pertain to anisopermeable media, heterogeneous fluids, or fluids in nonlaminar flow. Therefore, they have no great quantitative significance in actual oil-field practice, but their qualitative significance should not be underestimated. They show clearly just how much the productivity of a well would be affected by the constriction of the flow into liner slots, if that were the only departure from ideal radial flow conditions in the vicinity of the well bore. By isolating this one factor and showing the small magnitude of its effects, they indicate that practical decisions pertaining to liner slot sizes should be based primarily on other considerations, such as sand retention and mechanical strength.

Analytical Theory

Solution with Infinite Series

The three-dimensional character of the flow into a slotted liner is completely taken into account in the following analysis. The ingenious and simplifying assumption of Muskat[1a] that the impermeability of the liner can be accounted for by interference between pressure sinks has not been made.

Fig. 3 illustrates the flow section on which the analysis is based. The boundary conditions, which must be satisfied in addition to Laplace's equation, are as follows:

$$p = p_e : r = r_e \qquad [1]$$

$$p = p_w : \begin{cases} r = r_w \\ 0 < |\theta| < |\beta| \\ 0 < |z| < |b| \end{cases} \qquad [2]$$

$$\frac{\partial p}{\partial r} = 0 : \begin{cases} r = r_w \\ |\beta| < |\theta| < |\alpha| \\ |b| < |z| < |a| \end{cases} \qquad [3]$$

$$\frac{\partial p}{\partial \theta} = 0 : \theta = \pm\alpha \qquad [4]$$

$$\frac{\partial p}{\partial z} = 0 : \quad z = \pm a \qquad [5]$$

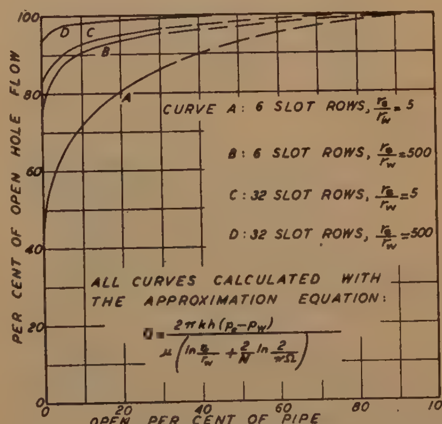

Fig. 2.—Dependence of flow into slotted liner upon radius ratio and number of slot rows.

Where:

r = the radial coordinate.

θ = the angular coordinate, measured from the center of the flow section.

z = the vertical coordinate, measured from the center of the flow section.

r_e = the external radius of the flow section.

r_w = the internal radius.

a = half of the flow-section height.

α = half of the section angle.

b = half of the slot length.

β = half of the slot angle.

p = the pressure at any point of the flow section.

p_e = the constant pressure over the external radius.

p_w = the constant pressure over the slot.

[1] References are at the end of the paper.

The function:

$$p = p_e - (p_e - p_w) \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} A_{n,m} \cos \left(\frac{n\pi\theta}{\alpha}\right) \cos\left(\frac{m\pi z}{a}\right) R_{n,m}* \quad [6]$$

satisfies Laplace's equation if

$$R_{0,0} = \frac{\ln\left(\frac{r}{r_e}\right)}{\ln\left(\frac{r_w}{r_e}\right)} \quad [7]$$

$$R_{n,0} = \frac{\left(\frac{r}{r_e}\right)^{\frac{n\pi}{\alpha}} - \left(\frac{r}{r_e}\right)^{-\frac{n\pi}{\alpha}}}{\left(\frac{r_w}{r_e}\right)^{\frac{n\pi}{\alpha}} - \left(\frac{r_w}{r_e}\right)^{-\frac{n\pi}{\alpha}}};\ n > 0,\ m = 0 \quad [8]$$

and

$$R_{n,m} = \frac{\dfrac{I_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r}{a}\right)}{I_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_e}{a}\right)} - \dfrac{K_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r}{a}\right)}{K_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_e}{a}\right)}}{\dfrac{I_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_w}{a}\right)}{I_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_e}{a}\right)} - \dfrac{K_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_w}{a}\right)}{K_{\frac{n\pi}{\alpha}}\left(\frac{m\pi r_e}{a}\right)}} \quad [9]$$

$n > 0,\ m > 0$

where I and K are modified Bessel functions of the first and second kinds, respectively.

In addition to Laplace's equation, the function of Eq. 6 satisfies also the boundary conditions 1, 4, and 5.

It remains to satisfy the mixed boundary conditions over the well face, $r = r_w$. For this purpose the double series of Eq. 6 must conform to the following equations:

$$\sum_{m=0}^{\infty} \sum_{n=0}^{\infty} A_{n,m} \cos\left(\frac{n\pi\theta}{\alpha}\right) \cos\left(\frac{m\pi z}{a}\right) R_{n,m} = 1$$

* Information on the use of such series is given by Smythe.[3]

When: $\begin{cases} r = r_w \\ 0 < |\theta| < |\beta| \\ 0 < |z| < |b| \end{cases}$ [10]

and

$$\sum_{m=0}^{\infty} \sum_{n=0}^{\infty} A_{n,m} \cos\left(\frac{n\pi\theta}{\alpha}\right) \cos\left(\frac{m\pi z}{a}\right) \frac{dR_{n,m}}{dr} = 0$$

When $\begin{cases} r = r_w \\ |\beta| < |\theta| < |\alpha| \\ |b| < |z| < |a| \end{cases}$ [11]

Eqs. 10 and 11 determine the coefficients $A_{n,m}$ formally; but the explicit, general calculation of the coefficients from those equations alone is a very difficult mathematical problem.[3] The following approximation method can be carried out to any desired degree of accuracy.

An approximate form for the function defining the normal derivative of the pressure over the slot area is assumed from physical considerations. The double series is then made to satisfy the conditions:

$$\sum_{m=0}^{\infty} \sum_{n=0}^{\infty} A_{n,m} \cos\left(\frac{n\pi\theta}{\alpha}\right) \cos\left(\frac{m\pi z}{a}\right) \frac{dR_{n,m}}{dr}$$

$$\begin{cases} = f(z, \theta): & \begin{cases} r = r_w \\ 0 < |\theta| < |\beta| \\ 0 < |z| < |b| \end{cases} \\ = 0 \quad : & \begin{cases} r = r_w \\ |\beta| < |\theta| < |\alpha| \\ |b| < |z| < |a| \end{cases} \end{cases} \quad [12]$$

where $f(z, \theta)$ is the assumed function.

The coefficients calculated from Eq. 12 are inserted in the series of Eq. 10, which corresponds to the condition that the pressure be constant over the slot area. When Eq. 10 is satisfied closely enough, a suitable function, $f(z, \theta)$ has been assumed, and suitable coefficients $A_{n,m}$ have been determined.

This procedure is somewhat similar to that used by Muskat[4a] in calculating poten-

tial distributions about partially penetrating wells, except that double series are involved instead of single series.

If it is not desired to calculate potential distributions; but fluxes only are required, a simpler procedure can be followed. A uniform flux density can be assumed over the slot and the average slot potential that will result can be calculated. It can then be assumed that approximately the same total flux would exist if the slot potential were constant at this average value, and the flux density were varied. This procedure was used in making the calculations of this paper. It is similar to one used by Muskat.[4b] In the present problem, it gives values correct to within one or two per cent.

The flux through the flow section of Fig. 3 is given by Eq. 13.

$$q = \frac{4k}{\mu} \int_0^b \int_0^\beta \left(\frac{\partial p}{\partial r}\right)_{r_w} r_w \, d\theta \, dz \quad [13]$$

Where:

q = the flux.
k = the permeability of the medium.
μ = the viscosity of the fluid.

Since the radial derivative of the pressure vanishes over parts of the well face other than the slot, the limits of integration in Eq. 13 may be enlarged to simplify the integration:

$$q = \frac{4kr_w}{\mu} \int_0^a \int_0^\alpha \left(\frac{\partial p}{\partial r}\right)_{r_w} d\theta \, dz$$

$$q = -\frac{4kr_w}{\mu} \int_0^a \int_0^\alpha \left[(p_e - p_w) \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} A_{n,m} \cos\left(\frac{n\pi\theta}{\alpha}\right) \cos\left(\frac{m\pi z}{a}\right) \left(\frac{dR_{n,m}}{dr}\right)_{r_w} \right] d\theta \, dz$$

$$q = -\frac{4kr_w\alpha a(p_e - p_w)}{\mu} \left(\frac{dR_{0,0}}{dr}\right)_{r_w} A_{0,0}$$

$$q = \frac{4k\alpha a(p_e - p_w)}{\mu \ln\left(\frac{r_e}{r_w}\right)} A_{0,0} \quad [14]$$

Since for a pipe segment of height h there must be

$$\frac{h}{2a} \times \frac{\pi}{\alpha}$$

flow sections, the total flux Q into the well is:

$$Q = \frac{2\pi kh(p_e - p_w)}{\mu \ln\left(\frac{r_e}{r_w}\right)} A_{0,0} \quad [15]$$

Eq. 15 is recognizable immediately as the familiar radial-flow equation, which

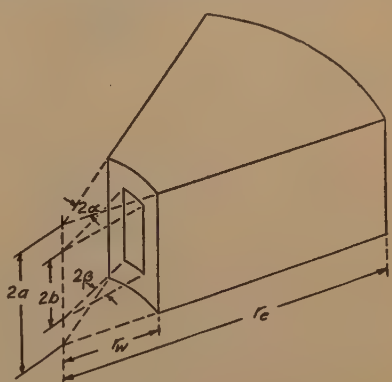

FIG. 3.—FLOW SECTION OF SLOTTED-LINER PROBLEM.

has been multiplied by the zero-zero coefficient of the series of Eq. 6. Since the zero-zero coefficient can be determined by the method given above, the general three-dimensional problem is solved.

Solution with Conformal Transformations

It is advantageous to investigate a simpler method for calculating the flux into the section of Fig. 3 when the slot length is equal to the section height; that is, $b = a$.

Infinite series are not needed for this calculation. The exact solution may be obtained by using a succession of conformal transformations (Fig. 4).

The first transformation straightens the radial-flow section into a constricted rectangular-flow section.

The second transformation unfolds the sides of the rectangular section onto the horizontal axis of an infinite half-plane.

The third transformation folds the flow section back again into a rectangle; but this time leaves it unconstricted, so that the flux through the section may be calculated.

$$z = C \int_0^\zeta \frac{d\zeta}{\sqrt{(\zeta - \xi_1)(\zeta - \xi_2)(\zeta - \xi_3)(\zeta - \xi_4)}} \quad [18]$$

This transformation, in which C is a constant, bends the ξ axis at the four

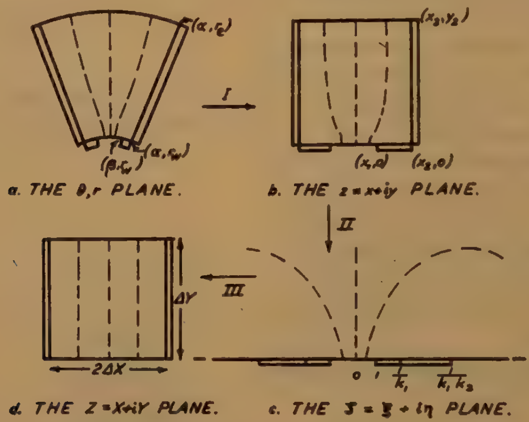

FIG. 4.—TRANSFORMATIONS FOR SOLVING TWO-DIMENSIONAL CASE.

The first transformation may be written:

$$z = x + iy = i \ln\left[\left(\frac{r}{r_w}\right)e^{-i\theta}\right]$$

$$= i\left[\ln\left(\frac{r}{r_w}\right) - i\theta\right] = \theta + i\ln\left(\frac{r}{r_w}\right)$$

so that $\quad x = \theta$

and $\quad y = \ln\left(\frac{r}{r_w}\right) \quad [16]$

According to Eqs. 16:

$$\left.\begin{array}{l} x_1 = \beta \\ y = 0 \end{array}\right\} \text{ when } \left\{\begin{array}{l} \theta = \beta \\ r = r_w \end{array}\right.$$

$$\left.\begin{array}{l} x_2 = \alpha \\ y = 0 \end{array}\right\} \text{ when } \left\{\begin{array}{l} \theta = \alpha \\ r = r_w \end{array}\right. \quad [17]$$

$$\text{and } \left.\begin{array}{l} x_2 = \alpha \\ y_2 = \ln\dfrac{r_e}{r_w} \end{array}\right\} \text{ when } \left\{\begin{array}{l} \theta = \alpha \\ r = r_e \end{array}\right.$$

These corresponding points are shown in the parentheses of Figs. 4*a* and 4*b*.

The second transformation, from the z-plane to the ζ-plane, is best written as its inverse, a transformation from the ζ-plane to the z-plane, by means of the Schwarz-Christoffel theorem:[4d]

points, ξ_1, ξ_2, ξ_3, and ξ_4, mapping the upper half of the ζ-plane onto a rectangle in the z-plane.

It is convenient to let:

$$C = \frac{D}{k_1k_2}$$

$$\xi_1 = -\frac{1}{k_1k_2}$$

$$\xi_2 = -\frac{1}{k_1}$$

$$\xi_3 = \frac{1}{k_1}$$

and

$$\xi_4 = \frac{1}{k_1k_2}$$

where k_1 and k_2 are constants to be determined. Eq. 18 may then be reduced to the form

$$z = x + iy = D\int_0^t \frac{dt}{\sqrt{(1 - t^2)(1 - k_2^2t^2)}} \quad [19]$$

where $t = k_1\zeta$.

The integral of Eq. 19 is in a standard form for an elliptic integral of the first kind.

According to Eq. 19:

$$\left.\begin{array}{l} x = DF(k_2, k_1) \\ y = 0 \end{array}\right\} \quad \text{when} \quad \left\{\begin{array}{l} \xi = 1 \\ \eta = 0 \end{array}\right.$$

$$\left.\begin{array}{l} x = DK(k_2) \\ y = 0 \end{array}\right\} \quad \text{when} \quad \left\{\begin{array}{l} \xi = \dfrac{1}{k_1} \\ \eta = 0 \end{array}\right.$$

and

$$\left.\begin{array}{l} x = DK(k_2) \\ y = DK'(k_2) \end{array}\right\} \quad \text{when} \quad \left\{\begin{array}{l} \xi = \dfrac{1}{k_1 k_2} \\ \eta = 0 \end{array}\right.$$

where $F(k_2, k_1)$ is an incomplete elliptic integral of the first kind with the modulus k_2, and the argument k_1; $K(k_2)$ and $K'(k_2)$ are, respectively, complete and complementary complete elliptic integrals of the first kind with the modulus k_2.*

To make the points where the ξ-axis is bent correspond to the corners of the original flow section, one may calculate k_1 and k_2 from the equations:

$$\frac{\beta}{\alpha} = \frac{F(k_2, k_1)}{K(k_2)} \qquad [20]$$

and

$$\frac{\alpha}{\ln \dfrac{r_e}{r_w}} = \frac{K(k_2)}{K'(k_2)}$$

in which the constant D is absent.

The third transformation, from the ζ-plane to the Z-plane, is also obtained from the Schwarz-Christoffel theorem:

$$Z = X + iY = B \int_0^\zeta \frac{d\zeta}{\sqrt{(\zeta - \xi_1)(\zeta - \xi_2)(\zeta - \xi_3)(\zeta - \xi_4)}} \qquad [21]$$

Here it is convenient to let

$$B = \frac{A}{k_1 k_2}$$

$$\xi_1 = -\frac{1}{k_1 k_2}$$

$$\xi_2 = -1$$

$$\xi_3 = 1$$

and

$$\xi_4 = \frac{1}{k_1 k_2}$$

* Tables of elliptic integrals are given by Pierce,[5] but those of Legendre[6] are more extensive.

where k_1 and k_2 are the already determined constants of the second transformation. Eq. 21 may then be reduced to

$$Z = X + iY = A \int_0^\zeta \frac{d\zeta}{\sqrt{(1 - \zeta^2)(1 - k_1^2 k_2^2 \zeta^2)}} \qquad [22]$$

The integral of Eq. 23 is an elliptic integral of the first kind with the modulus $k_1 k_2$.

According to Eq. 22:

$$\left.\begin{array}{l} X = AK(k_1 k_2) \\ Y = 0 \end{array}\right\} \quad \text{when} \quad \left\{\begin{array}{l} \xi = 1 \\ \eta = 0 \end{array}\right.$$

and

$$\left.\begin{array}{l} X = AK(k_1 k_2) \\ Y = AK'(k_1 k_2) \end{array}\right\} \quad \text{when} \quad \left\{\begin{array}{l} \xi = \dfrac{1}{k_1 k_2} \\ \eta = 0 \end{array}\right.$$

where $K(k_1 k_2)$ and $K'(k_1 k_2)$ are complete and complementary complete elliptic integrals of the first kind with the modulus $k_1 k_2$.

Letting these values of ξ be the points that correspond to the corners of the final flow section of Fig. 4*d*, we may write:

$$\frac{\Delta X}{\Delta Y} = \frac{K(k_1 k_2)}{K'(k_1 k_2)} \qquad [23]$$

an equation without the constant A, which will be of use later.

Now if pressures are given on the upper and lower faces of the unconstricted, rectangular section of Fig. 4*d*, it is possible to calculate the pressure at any point in that section. This is also the pressure at the corresponding point of the original constricted radial-flow section, which may be found using Eqs. 16 to 23. It is of interest here, however, to calculate only the flux through the original section.

The flux through the section of Fig. 4*d* may be written down upon inspection (in the terminology of Eq. 15):

$$q = \frac{2\Delta X kh(p_e - p_w)}{\mu \Delta Y} \qquad [24]$$

The ratio $\Delta X/\Delta Y$ is obtainable from Eq. 23 in terms of k_1 and k_2; and since these constants may be calculated from Eqs. 20 in terms of the dimensions of the

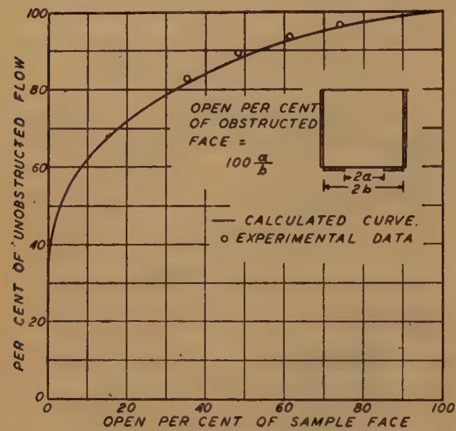

FIG. 5.—FLOW THROUGH CUBICAL CORE WITH PARTIALLY COVERED FACE.

original flow section, the problem is solved. Eqs. 20, 23, and 24 permit complete, exact calculations of the flux.

In calculations pertaining to the slotted liner, k_1 and k_2 are usually very small; hence it is possible to approximate the elliptic integrals as follows:

$$F(k_2, k_1) \cong k_1 \qquad [25]$$

$$K(k_2) \cong \frac{\pi}{2} \qquad [26]$$

$$K'(k_2) \cong \ln\left(\frac{4}{k_2}\right) \qquad [27]$$

With the aid of these relations, and the fact that there are π/α flow sections around the complete circumference of a liner, Eqs. 20, 23 and 24 may be reduced to Eq. 28:

$$Q = \frac{2\pi kh(p_e - p_w)}{\mu\left(\ln\frac{r_e}{r_w} + \frac{2}{N}\ln\frac{2}{\pi\Omega}\right)} \qquad [28]$$

where:

N = the number of slot rows.

Ω = the open fraction of pipe.

Eq. 28 is accurate to within one per cent when

$$\frac{r_e}{r_w} \geqslant 5 \qquad [29]$$

$$\Omega \leqslant 0.3 \qquad [30]$$

The accuracy improves as the radius ratio increases, and as the open fraction of pipe decreases.

Eq. 28 is also recognizable as the familiar radial-flow equation, with an added term in the denominator.

The Problem of the Obstructed Core Sample

The method used in treating the problem of the slotted liner in the two-dimensional case may be used to estimate the effect of partly covering the face of a core sample used for a permeability measurement. Some experimental results on this problem have been published by Carlson and Eastman.[7] The results obtained by these authors indicated that small errors are caused by facial coverages of the order of those that would be encountered in practice. However, the errors detected by Carlson and Eastman were of almost the same order of magnitude as their normal measurement errors, and the results, therefore, were erratic. For this reason, the following mathematical analysis gives an interesting and useful answer to the problem.

Consider a cubical core sample, one of whose faces is partly covered by two impermeable rectangular strips extending symmetrically from opposite edges of the face, and toward the center line of the face. A cross section of the core sample will be the form shown in Fig. 4*b*. The elliptic integral transformations of the foregoing discussion may be used therefore to calculate the flux through the sample. Fig. 5 shows the results of such calculations.

Fig. 5 also shows the results of an electrical analogy experiment made to check the theoretical calculations. From this

figure, it is apparent that for a 5 per cent error to occur in a permeability measurement, 30 per cent of the face would have to be obstructed. A 10 per cent coverage would cause an error of 1 per cent.

The results of Fig. 5 may be assumed to apply semiquantitatively to unsymmetrical facial obstructions on cubical core samples, and even to obstructions on the faces of cylindrical core samples of lengths approximately equal to their diameters. Cores whose lengths were greater in proportion to their facial dimensions would give even smaller errors.

Summary

1. The flux through a radial-flow system whose inner boundary is a slotted liner is approximated within one or two per cent by the following modification of the radial-flow formula:

$$Q = \frac{2\pi kh(p_e - p_w)}{\mu\left(\ln\frac{r_e}{r_w} + \frac{2}{N}\ln\frac{2}{\pi\Omega}\right)}$$

where N is the number of slot rows, and Ω is the open fraction of the pipe.

2. The small magnitude of the effects of constricting the flow of oil, gas, or water into liner slots indicates that decisions pertaining to liner-slot sizes should be based primarily upon other considerations, such as sand retention and strength.

3. In a permeability measurement on a core sample whose length is approximately equal to its diameter, or facial side, a 30 per cent facial coverage may cause only 5 per cent error in the result, whereas a 10 per cent coverage may cause but 1 per cent error.

Acknowledgment

The authors are grateful to the Standard Oil Company of California for permission to publish the material in this paper, and especially to Mr. E. G. Gaylord and Mr. J. E. Gosline for their inspiration and assistance.

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DISCUSSION

V. J. Beissinger.*—The effect of perforated liners on well productivity is complicated by a number of variable influences. How much the productivity of a well would be affected by the constriction of flow into a liner must be subject to an evaluation of the physical shapes and spaces involved. Reservoir hydraulics may be of considerable magnitude, but the behavior of producible wells illustrates the commonly known fact that subsurface remedial mechanics can be utilized to improve the rate and even the extent of oil-well productivity.

Each perforation may be visualized as an orifice, and the flow of oil and gas through each perforation will be limited to the capacity and characteristics of the orifice. A multiplicity of such perforations will accommodate the flow of oil and gas into a liner in a manner characteristic of multiple orifice performance expectancy. Thus, under one set of conditions in a well some of the perforations may react as nozzles, and under another set of conditions the same perforations might react as vertical submerged orifices.

It is the writer's belief that such physical reactions are the result of hydraulic effects immediate to the perforated liner, and that they may be of sufficient magnitude to affect the productivity of the well in spite of the reservoir hydraulics that completely surround the well bore. In this manner a perforated liner

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* Richfield Oil Corporation, Los Angeles, California.

might actually create a particular perforation block to most efficient well productivity.

It may be argued that *many* small round orifices should be less susceptible to reaction as a perforation block than a *few* rectangular slots of the same width because of the greater spread of pressure-drop points around the liner. Furthermore, with reference to Fig. 4, the "open per cent of pipe" relationship to "per cent of open-hole flow" should be considered within the range of actual perforated liner design, so that the 0 to 20 per cent portion would illustrate the most relevant practical range of comparative data. Thus, for 5 per cent of the pipe open, the respective flow values on curves A, B, C and D show a greater degree of contrast than for 20 per cent of the pipe open; and we know that most perforated liners fall below the 10 per cent point. Add to this relationship the orifice effects immediate to the liner, and we believe the "dependence of the flow into a slotted liner" might be further differentiated.

This paper is a noteworthy beginning for a most comprehensive study of such a live problem. The authors should be encouraged to go on both mathematically and experimentally, with added consideration for the empirical phases of actual oil-well production factors. Thus, the purely "qualitative significance" of the "one factor" developed in this paper might be the clue upon which the added significance of orifice effects could be resolved into a more practical determination of the problem.

We agree with the authors that sand retention and mechanical strength should be of prime consideration in the design of perforated liners, but we also believe that within the limits of proper design for those two elements there is much remaining ground for more appropriate attention to the effect of perforated liners on well productivity.

A Series of Enthalpy-entropy Charts for Natural Gases

By George Granger Brown*

(New York Meeting, February 1944)

Abstract

Enthalpy-entropy diagrams are presented for natural gases of 0.6, 0.7, 0.8, 0.9, and 1.0 gravity over the pressure range of 5 to 10,000 lb. per sq. in. and temperature range of 32° to 700°F. The charts indicate directly the work requirement and temperature rise for adiabatic compression or temperature change for free expansion of natural gases.

Computation and Uses of Charts

The Mollier diagram (Fig. 4), in which the enthalpy (heat content) is plotted against the entropy with lines of constant temperature, pressure, and in some cases volume, has been found most convenient when dealing with the compression, expansion, and flow of fluids. In dealing with the flow of fluids, the sum of the increase in the enthalpy, ΔH, plus the increase in kinetic energy, $\Delta M \frac{u^2}{2g}$, plus the increase in potential energy, ΔMZ, representing the total increase in energy of the fluid in flow, is equal to the sum of the heat q, and work added, $-w$, to the fluid while flowing between the entrance and exit of the flow system.

$$\Delta H + \Delta M \frac{u^2}{2g} + \Delta MZ = q - w \qquad [1]$$

In cases where there is no significant change in potential energy or in kinetic energy (velocity), it follows that the increase in enthalpy is equal to the total energy supplied to the fluid. Under such conditions the changes in the property of the fluid as it flows through a throttling valve, choke, or any other similar arrangement, may be read directly from the enthalpy-entropy diagram by following a horizontal line between the known pressures.

When compressing or expanding a gas by means of a compressor or engine in which no heat is added to or subtracted from the gas, but only work done, the changes in the properties of the gas may be determined along a vertical line of constant entropy between the entering and exit pressures. The power required for the compression of the gas may be readily determined by converting the increase in enthalpy into the desired units.

The enthalpy-entropy diagram for natural gases is to the gas engineer what the steam diagram is to the steam-power engineer. For this reason it would be extremely convenient if a reasonably satisfactory enthalpy-entropy diagram could be prepared as a function of the gravity of the gas. A careful study of the known properties of natural gas indicate that this is possible.

The effect of temperature upon the enthalpy at constant pressure is expressed as the "heat capacity" or "specific heat" of the gas. The best available data for natural and petroleum refinery gases indicates the relationship shown in Fig. 1. From this it is clear that the specific heat of natural gases is a function only of the gas gravity and the temperature at atmospheric pressure.

The effect of pressure on the enthalpy of natural gases is dependent upon the pressure-volume-temperature relationships.

Manuscript received at the office of the Institute Feb. 15, 1944. Issued as T.P. 1747 in Petroleum Technology, July 1944.

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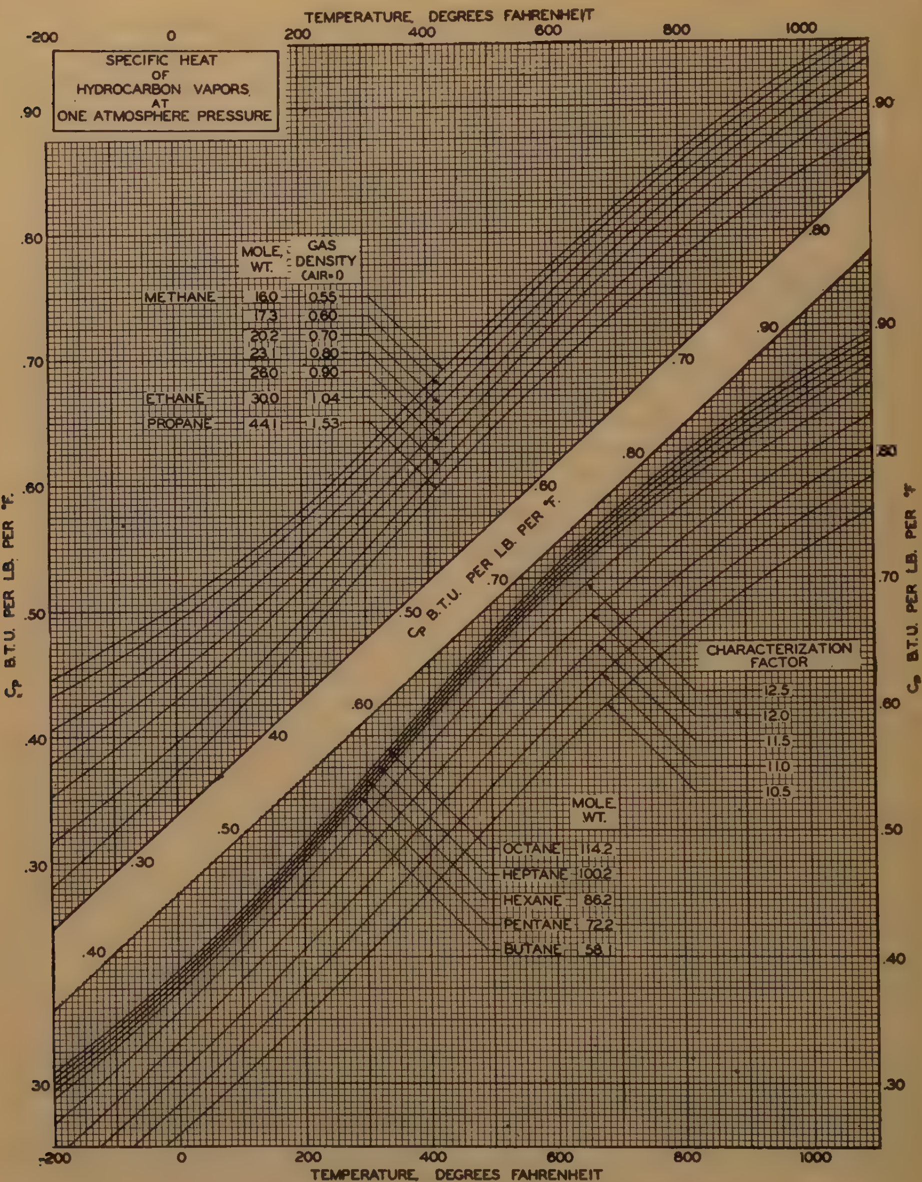

FIG. 1.—SPECIFIC HEAT OF HYDROCARBON VAPORS AT ONE ATMOSPHERE.

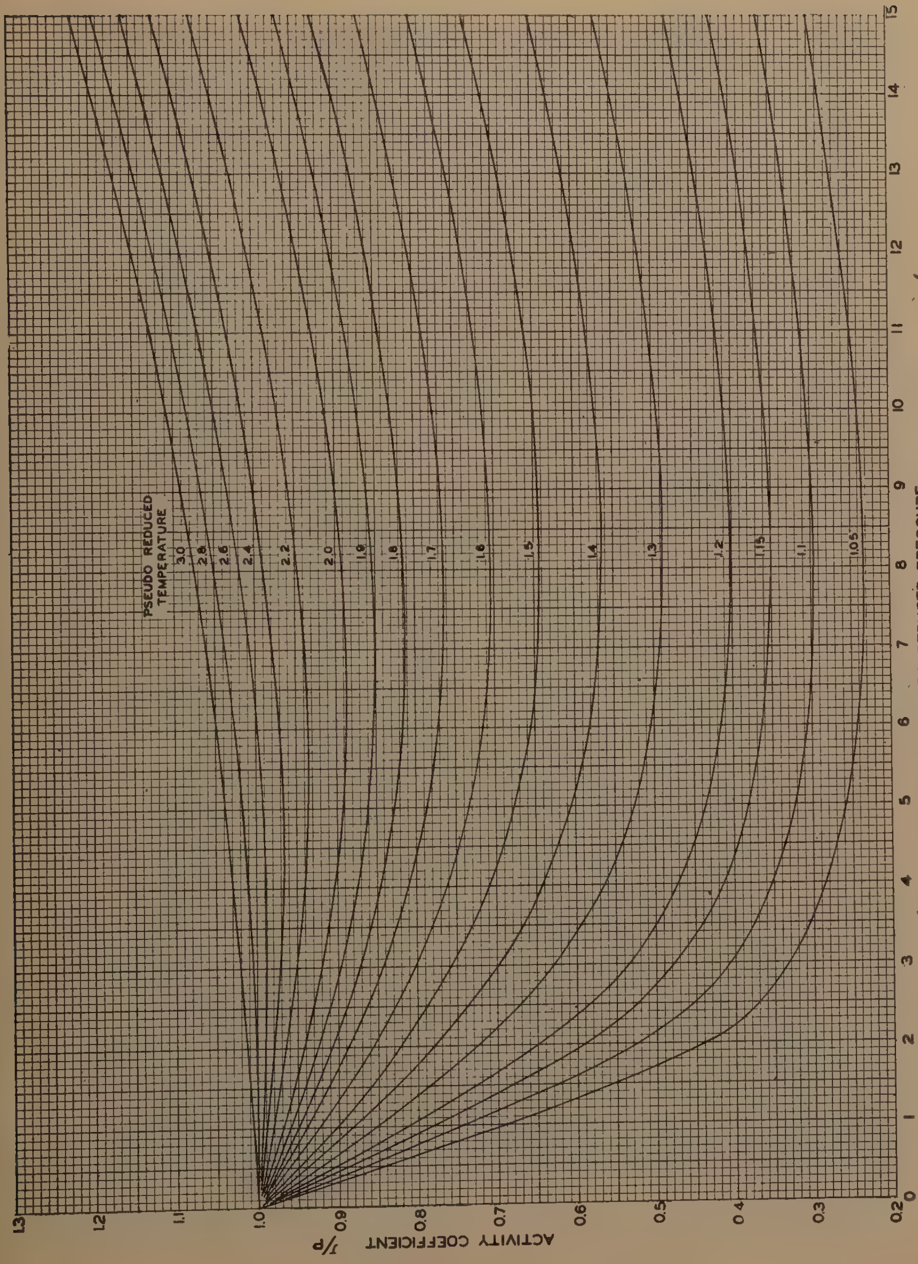

FIG. 2.—ACTIVITY COEFFICIENT FOR NATURAL GASES.

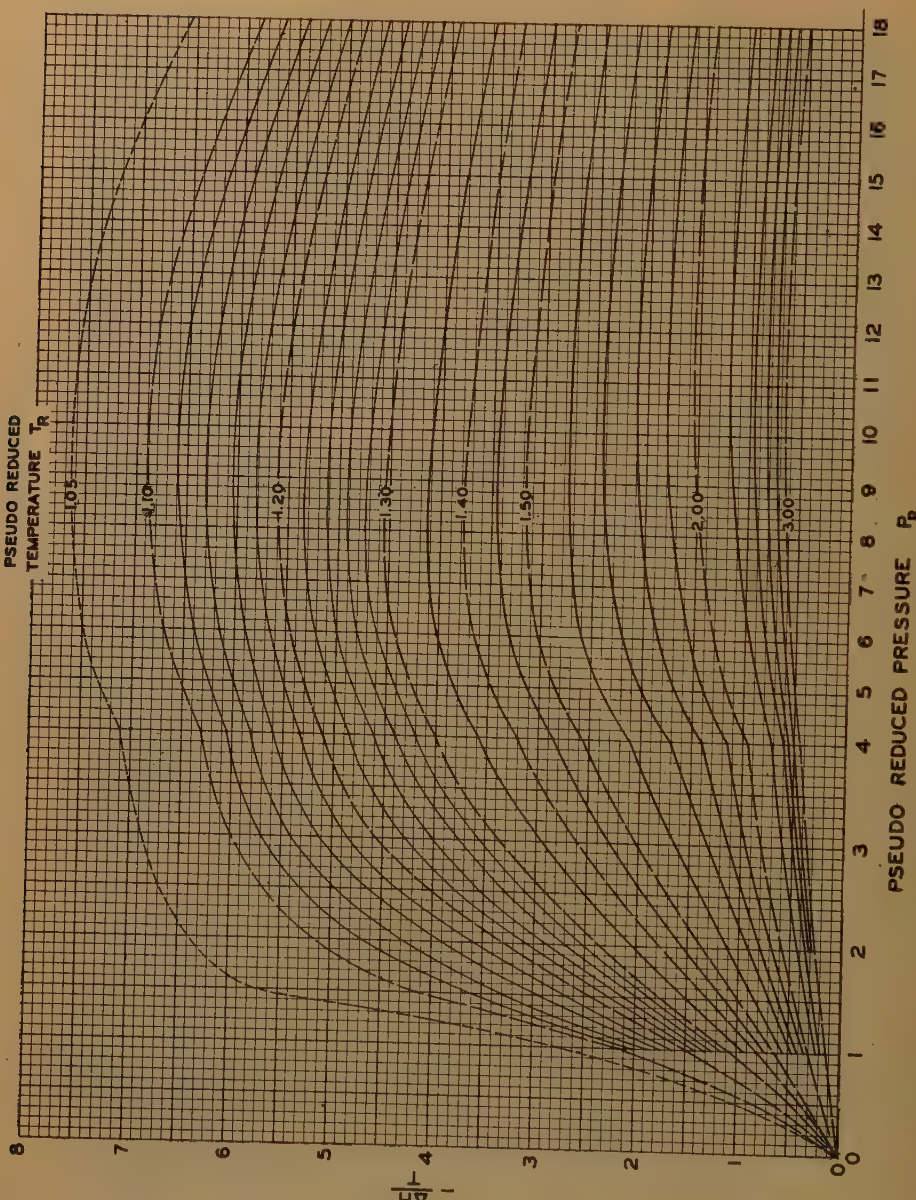

FIG. 3.—ISOTHERMAL CHANGES IN ENTHALPY FOR NATURAL GASES.

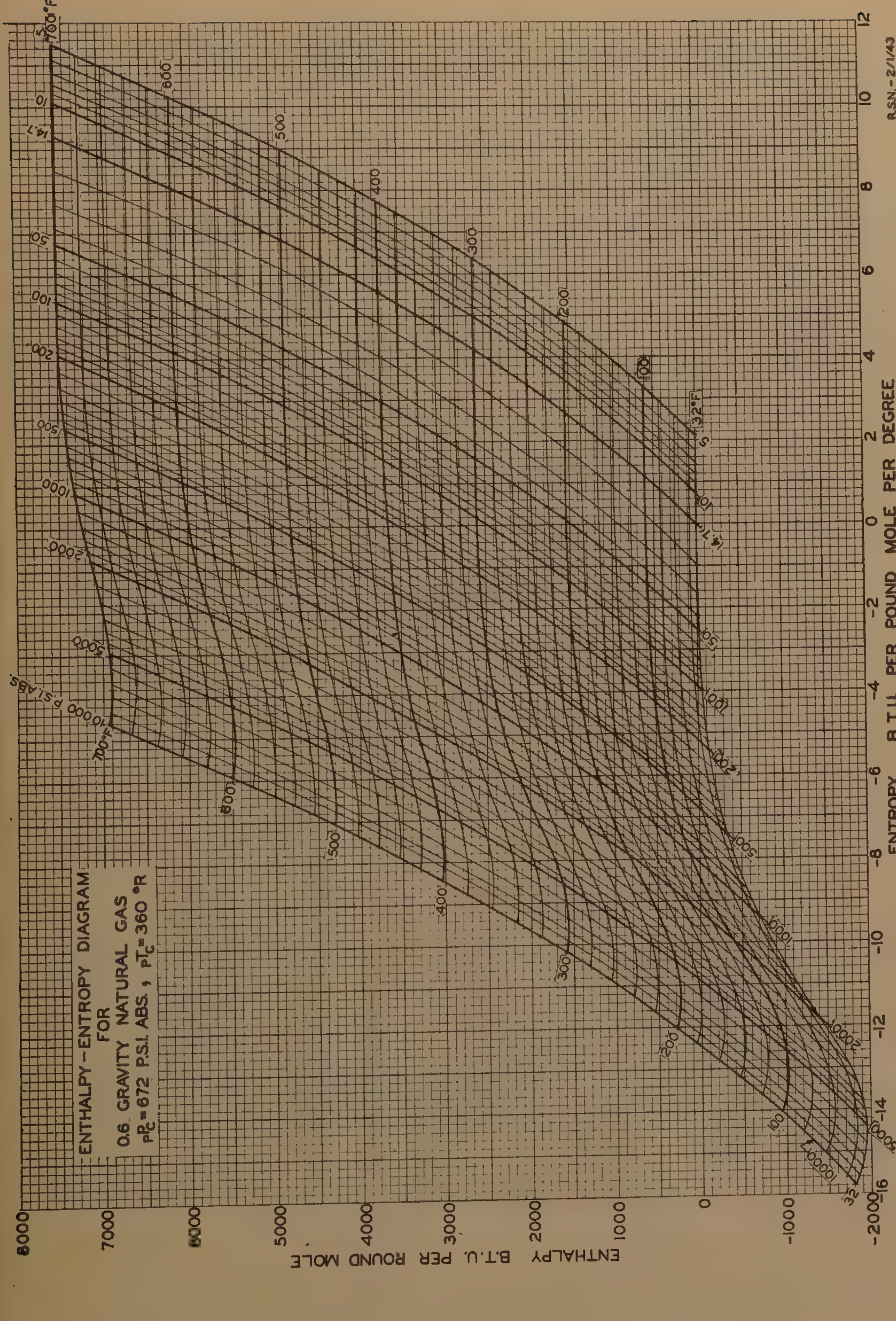

FIG. 4.—ENTHALPY-ENTROPY DIAGRAM FOR A 0.6 GRAVITY NATURAL GAS.

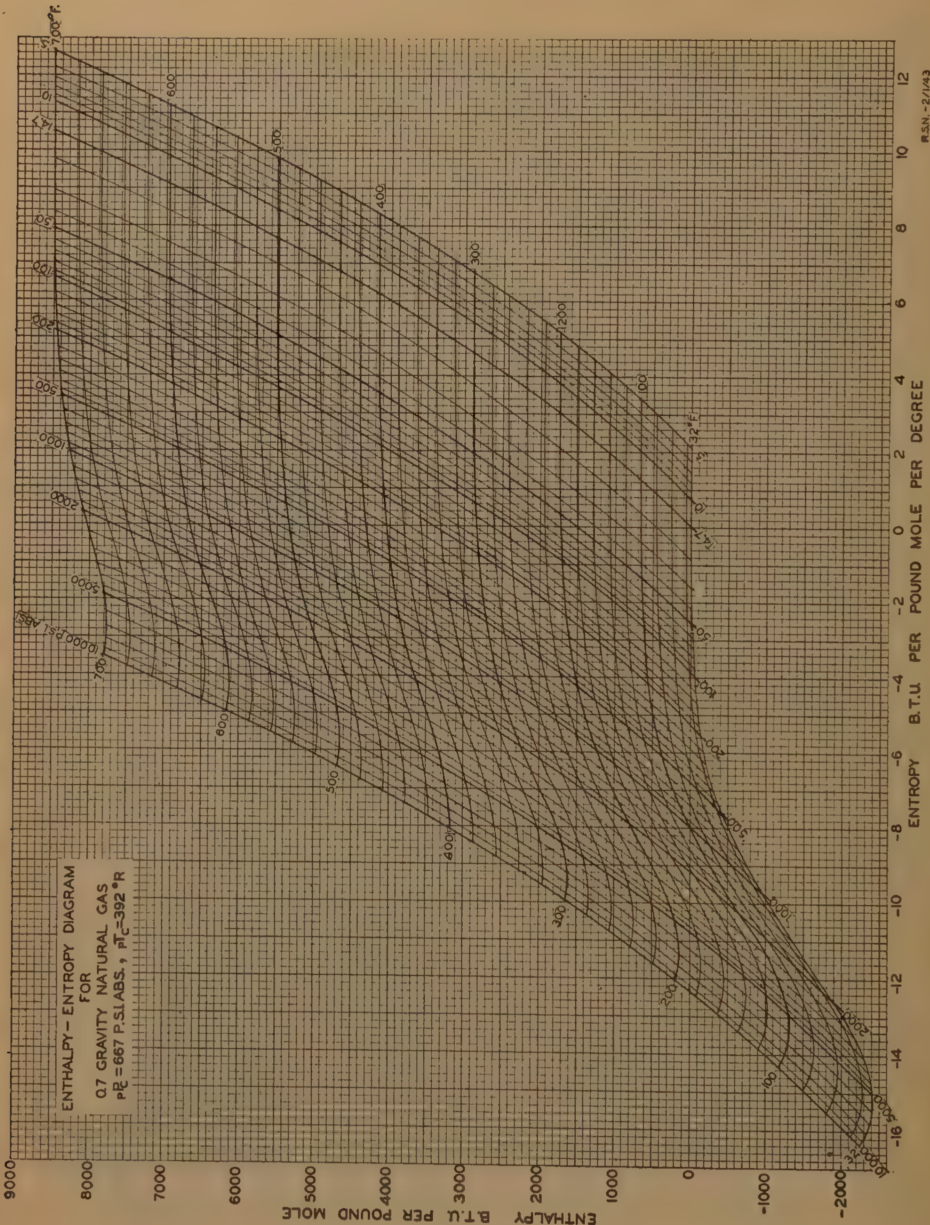

FIG. 5.—ENTHALPY-ENTROPY DIAGRAM FOR A 0.7 GRAVITY NATURAL GAS.

The combined effect of temperature and pressure is indicated by Eq. 2.

$$dH = MC_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] dP \quad [2]$$

at constant temperature

$$dH_T = \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] dP \quad [3]$$

The pressure-volume-temperature relationships for natural gases have been related with an accuracy of about ±2 per cent to the pseudoreduced pressure and pseudoreduced temperature through the compressibility factor and the following equation:

$$PV = zNRT \quad [4]$$

in which z is the compressibility factor added to the ideal gas equation in order to obtain accurate values for natural gases.[1] The pseudocritical pressure for a natural gas is the molal average critical pressure obtained by multiplying the critical pressure of each component of the gas by the mol fraction of that component in the gas and adding these products for all components. The reduced pressure is obtained by dividing the absolute pressure by the absolute critical pressure.

This sounds rather complicated, but fortunately the pseudocritical pressure and pseudocritical temperature may be approximated in a reasonably satisfactory manner from the gas gravity.[2]

It is therefore possible to determine the effect of temperature and pressure upon the enthalpy of natural gases from simply a determination of the gas density. In order to complete the work with the preparation of an enthalpy-entropy diagram, the additional preliminary Figs. 2 and 3 were prepared. Since $T = T_rT_c$ and $P = P_rP_c$, by definition,

[1] M. B. Standing and D. L. Katz: *Trans.* A.I.M.E. (1942) **146**, 140.

[2] D. L. Katz: *Proc.* Nat. Gas. Assn. of Amer. (1942) 47; *Refiner* (1942) **21** (6), 58.

$$dH_T = \left\{\frac{zRT}{P_rP_c} - RT\left[\frac{z}{P_rP_c} + \frac{T_rT_c}{P_rP_r}\left(\frac{\partial z}{T_c\partial T_r}\right)_{P_r}\right]\right\} P_c dP_r$$

$$\frac{dH_T}{T} = -\frac{RT_r}{P_r}\left(\frac{\partial z}{\partial T_r}\right) dP_r - \frac{\Delta H_T}{T} = R\int_{P_r=0}^{P_r=P_r} T_r\left(\frac{\partial z}{\partial T_r}\right)_{P_r} dP_r \quad [5]$$

It is therefore possible to prepare Fig. 3 by integration of Eq. 5. The values for $\left(\frac{\partial z}{\partial T_r}\right)_{P_r}$ are determined by plotting z as a function of T_r for lines of constant P_r and differentiating graphically for $\left(\frac{\partial z}{\partial T_r}\right)_{P_r}$. These values are then used in Eq. 5 and the integration accomplished graphically by plotting $\left(\frac{\partial z}{\partial T_r}\right)_{P_r}$ against P_r for lines of constant T_r and getting the areas under the curves from $P_r = 0$.

Similarly,

$$dS = \frac{C_p}{T} dT - \left(\frac{\partial V}{\partial T}\right)_P dP \quad [6]$$

at constant temperature

$$dS = -\left(\frac{\partial V}{\partial T}\right)_P dP \quad [7]$$

In terms of reduced temperature T_r and reduced pressure P_r,

$$dS = -R\left[\frac{z}{P_rP_c} + \frac{T_rT_c}{P_rP_c}\left(\frac{\partial z}{T_c d T_r}\right)_{P_r}\right] P_c dP_r$$

$$\int dS = -\int R\left[z + \left(\frac{\partial z}{\partial \ln T_r}\right)_{P_r}\right] d \ln P_r \quad [8]$$

which may be solved by graphical methods as for Eq. 5, using a particular reference pressure. A more convenient procedure, which also gives information concerning the fugacity, is by use of the following equations:

$$d \ln f = d \ln P - \frac{1 - z}{P} dP$$

$$d \ln \frac{f}{P} = -\frac{1 - z}{P} dP$$

$$d \ln \frac{f}{P} = -\frac{1 - z}{P_r P_c} P_c dP_r = \frac{1 - z}{P_r} dP_r$$

$$\ln \frac{f}{P} = \int_{P_r = 0}^{P_r = P_r} (z - 1) d \ln P_r \qquad [9]$$

Eq. 9 may be integrated graphically by a single operation to obtain Fig. 2.

Fig. 3 is computed from Fig. 2 by means of the following relationships:

$$F_2 - F_1 = RT \ln \frac{f_2}{f_1} = RT \ln f_2 - RT \ln f_1$$

$$\frac{F_2}{T} - \frac{F_1}{T} = R \ln \frac{f_2}{f_1}$$

differentiating with respect to T

$$\frac{\partial F_2}{\partial T} - \frac{\partial F_1}{\partial T} = R \ln \frac{f_2}{f_1} + RT \left(\frac{\partial \ln f_2}{\partial T}\right)_P - RT \left(\frac{\partial \ln f_1}{\partial T}\right)_P$$

substituting for $R \ln \frac{f_2}{f_1}$

$$\frac{\partial F_2}{\partial T} - \frac{\partial F_1}{\partial T} = \frac{F_2}{T} - \frac{F_1}{T} + RT \left(\frac{\partial \ln f_2}{\partial T}\right)_P - RT \left(\frac{\partial \ln f_1}{\partial T}\right)_P$$

$$\left(\frac{\partial F}{\partial T}\right)_P = \frac{F - H}{T}$$

$$\left(\frac{F_2}{T} - \frac{H_2}{T}\right) - \left(\frac{F_1}{T} - \frac{H_1}{T}\right) = \frac{F_2}{T} - \frac{F_1}{T} + RT \left(\frac{\partial \ln f_2}{\partial T}\right)_P - RT \left(\frac{\partial \ln f_1}{\partial T}\right)_P$$

If state 1 is taken at a low pressure, so that $f_1 = P_1$, the last term becomes 0, and since P is constant for any differential at constant pressure

$$-\frac{H_2 - H_1}{T} = RT \left(\frac{\partial \ln \frac{f}{P}}{\partial T}\right)_P$$

$$\frac{-\Delta H}{T} = R \left[\frac{\ln \frac{f}{P}}{\ln T_r}\right]_{P_r} \qquad (10)$$

The last term is evaluated by plotting $\ln \frac{f}{P}$ against $\ln T_r$ from Fig. 2 and differentiating graphically. In preparing the enthalpy-entropy diagram, Figs. 4 through 8, a reference state of 0 enthalpy was chosen for each gas at 32°F. and 14.7 lb. per sq. in. abs. Using this as the starting point, the enthalpy at atmospheric pressure could be determined for all temperatures for each gravity of gas by use of the data of Fig. 1 and the following equation:

$$\Delta H_p = \int MC_p dT$$

Similarly, the reference state for the entropy of all gases was taken as 32°F. and 14.7 lb. per sq. in. abs. The entropy for all temperatures and each gas was then computed by means of the data in Fig. 1 and the following relationship:

$$\Delta S_p = \int \frac{MC_p}{T} dT$$

At this point the data at each 100°F. were cross plotted as a function of the gravity of the gas, in order to eliminate any errors or irregularities in calculation. The enthalpy was then plotted as a function of entropy, establishing the constant pressure line of 14.7 lb. per sq. in. abs. on each of Fig. 6 through 10.

The enthalpy at 5, 10, 50, 100, 200, 500, 1000, 2000, 5000, and 10,000 lb. per sq. in. abs. was then computed for each 100°F. using the data obtained for these temperatures at one atmosphere pressure and the data on Fig. 3.

Similarly, the entropy at these pressures and even 100°F. was computed from the data just obtained and the use of Fig. 2 as follows:

$$\frac{\Delta H - \Delta F}{T} = \Delta S$$

$$\frac{\Delta H - RT \ln \frac{f_2 P_1}{P_2 f_1}}{T} = \Delta S$$

As before, the enthalpy at specified temperatures and pressures were cross

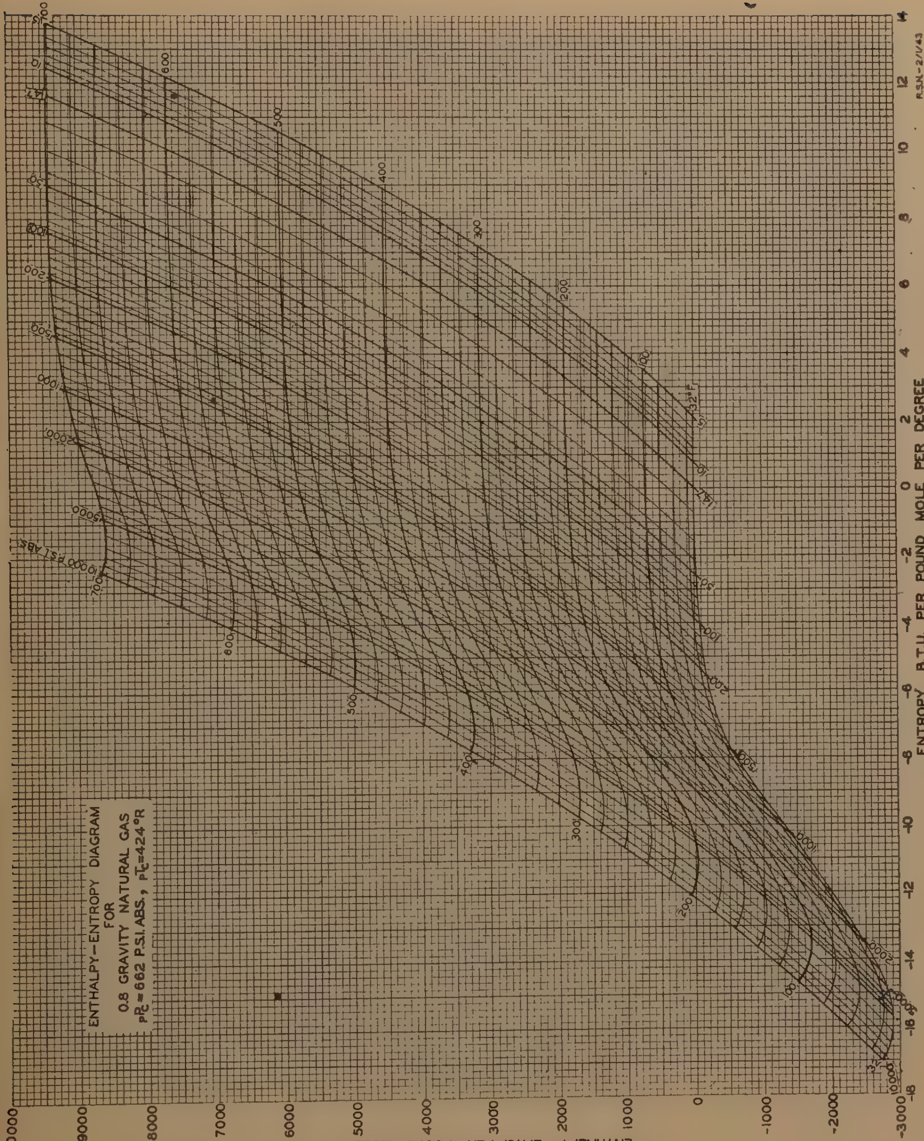

FIG. 6.—ENTHALPY-ENTROPY DIAGRAM FOR A 0.8 GRAVITY NATURAL GAS.

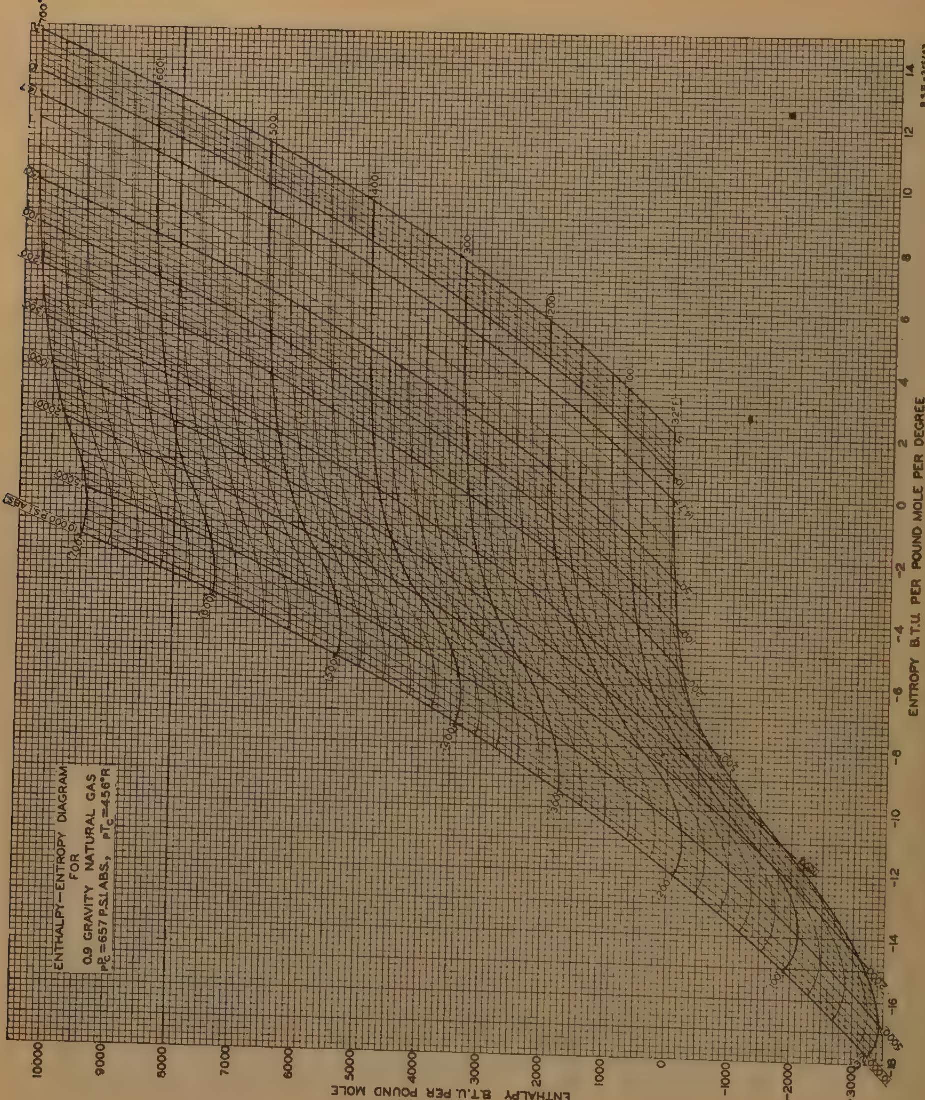

FIG. 7.—ENTHALPY-ENTROPY DIAGRAM FOR A 0.9 GRAVITY NATURAL GAS.

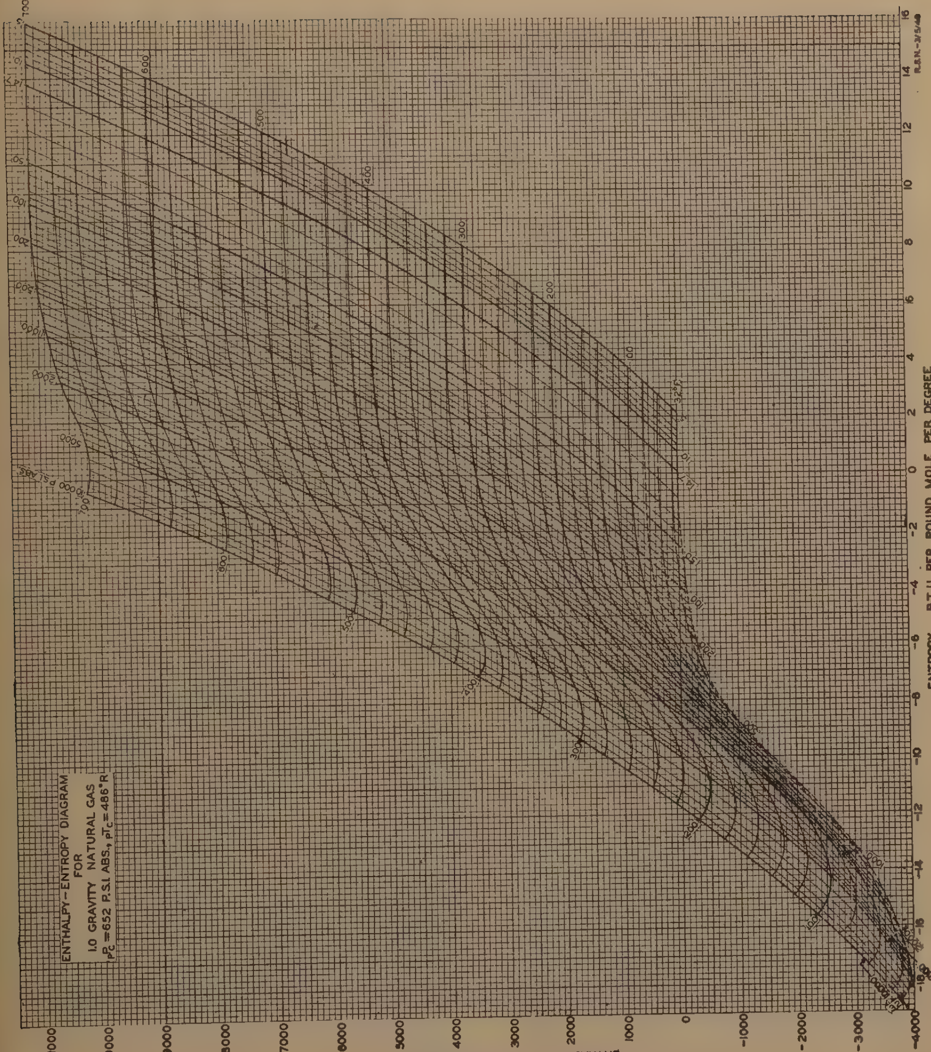

FIG. 8.—ENTHALPY-ENTROPY DIAGRAM FOR 1.0 GRAVITY NATURAL GAS.

plotted as a function of gas gravity as a means of checking errors and irregularities in computations. It was found that the computations themselves fell on consistent smooth lines and no significant leveling of the data was required.

The final data were plotted as indicated in Figs. 4 through 8 and the intermediate pressures and temperatures were interpolated. These charts may be used in the same manner as the $H - S$ diagram for steam. For convenient estimates of the temperature drop on free expansion, follow a constant enthalpy horizontal line. For the increase in enthalpy on adiabatic compression, follow a constant entropy vertical line. The charts are also suitable for plotting Fanno and Rayleigh lines in the study of high-velocity flow, as described in various texts on thermodynamics.

Acknowledgment

These plots, among others for natural gases containing nitrogen, were prepared by J. T. Banchero, N. Fatica, W. Harbert, J. L. McCurdy, M. J. Rzosa, G. W. Preckshot, and C. McKinley, graduate students in chemical engineering (1942) at the University of Michigan. R. S. Neymark, a senior in chemical engineering, inked the original charts.

Volumetric and Phase Behavior of Oil and Gas from Paloma Field

By R. H. Olds,* B. H. Sage,* Member A.I.M.E., and W. N. Lacey*

(Los Angeles Meeting, October 1944)

Abstract

Samples of liquid and gas were obtained from the primary separator of a well in the Paloma field. The volumetric properties of the samples and of six systematically chosen mixtures of the samples were experimentally determined at 100°, 190°, and 250°F. at pressures up to 5000 lb. per sq. inch.

From these data the influence of pressure and temperature upon the composition and specific volume of the bubble-point liquid and of the retrograde dew-point gas was established. The formation volumes and gas-oil ratios of the mixtures investigated were calculated on the basis of the plant-product oil, which is defined as the isobutane and less volatile portion of each mixture. The results are presented in graphical and tabular form.

The volumetric behavior of the mixture corresponding to that produced by the well at the time of sampling was determined for 235°F., the reported reservoir temperature, by graphical interpolation of the experimental data with respect to composition and temperature. The results indicate that the well-production mixture probably existed as a gas at its retrograde dew point under the conditions of temperature and pressure believed to prevail in the producing zone at the time of sampling.

The effect upon the phase behavior occasioned by the omission from the well-production mixture of certain components of intermediate molecular weight was investigated. In the first case, all of the isobutane and n-butane, and substantially all of the isopentane, were removed from the mixture of trap samples corresponding to the well production. In the second case, all the propane, isobutane and n-butane, and substantially all of the isopentane, were removed. Both modifications led to considerable increases in the retrograde dew-point pressure at 235°F.; an increase of 558 lb. per sq. in. above that of the unmodified well-production mixture in the first case, and an increase of 1208 lb. per sq. in. in the second.

It was concluded that the materials remaining after the removal of certain components of intermediate molecular weight could not be injected back into the reservoir in the same proportion in which they were produced without entailing appreciable loss of liquid material through condensation within the formation.

Introduction

Under the usual conditions of production practice, petroleum arrives at the surface of the earth in a physical state considerably different from that in which it existed in the underground reservoir. The relative rates of production and the properties of oil and gas measured at surface conditions do not constitute, in general, even a qualitative description of the fluids existing in the reservoir.

The estimation of reserves and the attainment of optimum efficiency with regard to rate, quantity, and cost of production require accurate data concerning the physical properties of petroleum throughout large changes in pressure and temperature. Many schemes have been devised for predicting the behavior of petroleum as it is encountered in nature, but the experimental work upon which these predictions are based has not, for the most part, been extended to the higher pressures that occur in practice, nor do these methods permit, as yet, the estima-

Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1861 in Petroleum Technology, May 1945.
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tion of the behavior of mixtures in the vicinity of their critical state.[1–7] The requisite exact information can be obtained only by the experimental measurement of the properties of the materials under consideration at pressures and temperatures encompassing the ranges of these variables involved in production practice.

TABLE 1.—*Sampling Conditions*

Field: Paloma
Well: Western Gulf Oil Co., KCL 54-3
Location: Sec. 3, T 32S, R26E, Kern County, California
Depth to midpoint of producing sand: 10,097 feet

PRODUCTION CONDITIONS	
Date of sampling, July 11, 1940	
Tubing pressure, lb. per sq. in. abs	2,295
Casing pressure, lb. per sq. in. abs	3,240
High-pressure separator:	
Pressure, lb. per sq. in. abs	436
Gas rate, cu. ft. per day[a]	979,000
Temperature of gas, deg. F	98.5
Low-pressure separator:	
Pressure, lb. per sq. in. abs	63
Gas rate, cu. ft. per day	60,000
Temperature of gas, deg. F	115
Vent tank:	
Pressure	Atmospheric
Gas rate, cu. ft. per day	25,000
Oil rate, bbl. per day	157
Gas-oil ratio, cu. ft. per bbl.[b]	6,777
Subsurface conditions:	
Pressure, lb. per sq. in. abs	4,825[c]
Temperature, deg. F	235

[a] Measurements of gas and liquid production rates have been reduced to standard conditions; i.e., 60°F. and 14.73 lb. per sq. in. abs.
[b] Tank-oil basis.
[c] Doubtful value. Subsequent measurements indicated a subsurface pressure of 4700 lb. per sq. in. abs.

For these reasons it was decided to determine by an experimental laboratory investigation the volumetric and phase behavior of gas and oil mixtures from Paloma field. Information pertaining to the state of the hydrocarbon mixture corresponding in composition to that of the well-production mixture at reservoir temperature and pressure was the primary objective of the initial investigation. This work was carried out as a part of the California Production Project at the California Institute of Technology during the fall of 1940.

A subsequent investigation of modified materials from the same well was undertaken to determine how the phase behavior of the well-production mixture is affected by the extraction of several components of intermediate molecular weight. The objective in this case was to measure the amount of condensate loss to be anticipated in a proposed plan to return to the reservoir the residue gas and natural gasoline remaining after the extraction of certain components of immediate commercial value. This work was performed under a special grant of funds from The Texas Company, and was completed in the summer of 1942.

[1] References are at the end of the paper.

TERMINOLOGY

The samples of hydrocarbon liquid and gas phases obtained from the primary surface separator of the well are designated by the terms "trap liquid" and "trap gas," respectively. These are the constituents that were combined in various proportions to produce the mixtures of which the volumetric properties were studied.

TABLE 2.—*Composition of Trap Samples*

Component	Gas: Mol Fraction	Gas: Weight Fraction	Liquid: Mol Fraction	Liquid: Weight Fraction
Methane	0.8255	0.6516	0.0966	0.0156
Ethane	0.0901	0.1333	0.0403	0.0122
Propane	0.0462	0.1004	0.0877	0.0389
Isobutane	0.0074	0.0212	0.0307	0.0180
n-Butane	0.0126	0.0361	0.0759	0.0444
Isopentane	0.0032	0.0114	0.0357	0.0259
n-Pentane	0.0022	0.0078	0.0438	0.0318
Hexanes and heavier	0.0038[a]	0.0187	0.5893[b]	0.8132
Carbon dioxide	0.0090	0.0195		
Average molecular weight	20.316		99.35	
Gas-oil ratio[c]	40,108		243	

[a] Assumed average molecular weight, 99.64.
[b] Average molecular weight as determined from freezing point lowering of benzene extrapolated to infinite dilution of the solute 137.1.
[c] Plant-product basis.

The "tank oil" is the sample of liquid drawn from the vent tank of the well. The nature of this liquid depends upon the separator conditions and is subject to considerable seasonal variation in composition where the surface separator system is exposed to the weather.

The "plant product" is an arbitrarily defined oil, which in this report is taken to be composed of the total isobutane and

less volatile portion of the mixture under consideration.

TABLE 3.—*Properties of Hexanes-and-heavier Portion of Trap-liquid Sample*

Mol fraction of trap-liquid sample, 0.5893
Weight fraction of trap-liquid sample, 0.8132
Gravity at 60°F. and 14.73 lb. per sq. in. abs., 46.1°A.P.I.
Specific volume at 60°F. and 14.73 lb. per sq. in. abs., 0.020113 cu. ft. per lb.
Kinematic viscosity: 77°F., 1.37 centistokes
100°F., 1.15 centistokes
Viscosity gravity factor, 0.820
Average boiling point, 364°F.
Average molecular weight, 137.1[a]

FRACTIONATION ANALYSIS

Cut No.	Gravity Deg. A.P.I.	Kinematic Viscosity, Centistokes		Viscosity Gravity Factor	Average Boiling Point[b]	Approx. Molecular Weight	Weight Fraction[c]
		77°F.	100°F.				
1	64.7	0.566	0.507	0.773	161	93	0.1022
2	58.4	0.659	0.584	0.793	211	100	0.1055
3	53.1	0.759	0.669	0.811	254	109	0.1086
4	47.8	0.975	0.903	0.822	312	128	0.1118
5	41.7	1.64	1.28	0.840	392	155	0.1157
6	36.3	3.45	2.63	0.843	491	204	0.1195
Residue.	28.9	21.29	13.08	0.849	670	274	0.1499

[a] Determined from freezing-point lowering of benzene extrapolated to infinite dilution of the solute.
[b] Derived from gravity and viscosity gravity factor.
[c] Based upon entire trap-liquid sample.

The "gas-oil ratio" of a mixture represents the number of cubic feet of gas associated with a barrel of oil, both volumes being measured at 60°F. and 14.73 lb. per sq. in.* The numerical value of the gas-oil ratio depends upon the nature of the materials selected as gas and oil. In field operations the gas-oil ratio of the hydrocarbon mixture produced from a well is based upon production rates of separator gas and tank oil, because these are easily measured quantities. However, the variable nature of these constituents makes this basis not entirely satisfactory. Gas-oil ratios computed from an arbitrary separation of the components of the mixture into a gaseous constituent composed of all components more volatile than isobutane and an oil in accordance with the plant product is gaining widespread acceptance, because it has significance in refinery practice and because it is a single-valued indicator of composition independent of the vagaries of a surface separator system. In this paper the basis upon which the gas-oil ratios are computed is indicated by footnotes distributed throughout the tables. With few exceptions, the plant-product basis is used.

* Throughout this paper pressure is expressed in pounds per square inch absolute.

TABLE 4.—*Composition of Vent-tank Oil*[a]

Component	Mol Fraction	Weight Fraction
Methane		
Ethane		
Propane	0.0300	0.0110
Isobutane	0.0215	0.0104
n-Butane	0.0664	0.0320
Isopentane	0.0481	0.0287
n-Pentane	0.0531	0.0317
Hexanes and heavier	0.7809[b]	0.8862

[a] Average molecular weight, 120.7. Gravity at 60°F., 14.73 lb. per sq. in., 52.9°A.P.I. Specific volume at 60°F., 14.73 lb. per sq. in., 0.02089 cu. ft. per lb.
[b] Assumed to be practically identical in composition to the corresponding portion of the trap-liquid sample.

TABLE 5.—*Compressibility Factor of the Trap Gas*[a]

Pressure, Lb. per Sq. In. Abs.	100°F.	190°F.	235°F.	250°F.
0	1.0000	1.0000	1.0000	1.0000
200	0.9674	0.9809	0.9858	0.9871
400	0.9350	0.9626	0.9721	0.9745
600	0.9015	0.9450	0.9597	0.9634
800	0.8695	0.9288	0.9479	0.9530
1,000	0.8400	0.9135	0.9368	0.9431
1,250	0.8087	0.8970	0.9251	0.9331
1,500	0.7823	0.8832	0.9160	0.9255
1,750	0.7625	0.8717	0.9078	0.9183
2,000	0.7495	0.8647	0.9044	0.9155
2,250	0.7445	0.8609	0.9038	0.9155
2,500	0.7450	0.8639	0.9072	0.9188
2,750	0.7516	0.8683	0.9113	0.9229
3,000	0.7653	0.8755	0.9172	0.9289
3,500	0.8040	0.9003	0.9367	0.9472
4,000	0.8516	0.9302	0.9610	0.9700
4,500	0.9014	0.9634	0.9890	0.9969
5,000	0.9538	1.0005	1.0216	1.0282

[a] Composition given in Table 2.

The "formation volume" is the ratio of the volume of the mixture, measured at the pressure and temperature under consideration, to the volume of oil associated with that mixture, measured at 60°F. and 14.73 lb. per sq. in. The numerical value of the formation volume depends upon the

TABLE 6.—*Volumetric Properties of Trap Liquid*

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (352)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (483)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (600)[a]	Formation Volume[b]	Liquid Formation Volume
B.P.	0.02246	0.02246	1.148	1.148	0.02394	0.02394	1.223	1.223	0.02520	0.02520	1.288	1.288
200	0.03945	0.02165	2.016	1.030	0.06535	0.02165	3.340	1.106		0.02232		1.141
400	0.02245		1.147		0.02918	0.02340	1.491	1.196	0.03796	0.02378	1.940	1.215
600	0.02240		1.145		0.02389		1.221		0.02520	0.02520	1.288	1.288
800	0.02236		1.143		0.02382		1.217		0.02510		1.283	
1,000	0.02231		1.140		0.02374		1.213		0.02499		1.277	
1,250	0.02226		1.138		0.02366		1.209		0.02487		1.271	
1,500	0.02220		1.135		0.02357		1.205		0.02476		1.265	
1,750	0.02216		1.133		0.02349		1.200		0.02465		1.260	
2,000	0.02211		1.130		0.02341		1.196		0.02454		1.254	
2,250	0.02207		1.128		0.02333		1.192		0.02444		1.249	
2,500	0.02202		1.125		0.02326		1.189		0.02434		1.244	
2,750	0.02198		1.123		0.02319		1.185		0.02425		1.239	
3,000	0.02194		1.121		0.02313		1.182		0.02416		1.235	
3,500	0.02187		1.118		0.02300		1.175		0.02400		1.227	
4,000	0.02180		1.114		0.02289		1.170		0.02385		1.219	
4,500	0.02174		1.111		0.02279		1.165		0.02371		1.212	
5,000	0.02168		1.108		0.02269		1.160		0.02358		1.205	

[a] Figures in parentheses represent bubble-point pressures expressed in pounds per square inch absolute.
[b] Formation volume is based upon the plant product.

material selected as oil. All formation volumes herein reported are expressed in terms of the plant product.

The "liquid volume" is the number of cubic feet of liquid phase associated with one pound of the mixture measured at the conditions under consideration. The liquid volume should not be confused with the "specific volume" of the liquid phase. The specific volume of the liquid phase is the volume of a unit weight of the liquid phase, while the liquid volume is the volume of the liquid phase present in a unit weight of the entire mixture.

conditions described with regard to formation volume in the preceding paragraph. It is apparent that throughout the heterogeneous region the formation volume and the liquid formation volume are distinct from one another. However, at the bubble point they become identical, and at the dew point the liquid formation volume vanishes.

Materials

Samples of hydrocarbon gas and liquid were obtained on July 11, 1940, from the primary separator of the Western Gulf Oil

TABLE 7.—*Composition of Experimentally Studied Mixtures*

Weight fraction trap gas	0.0571		0.1213		0.2867	
Component	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction
Methane	0.2630	0.0519	0.3902	0.0927	0.5797	0.1980
Ethane	0.0516	0.0191	0.0604	0.0269	0.0733	0.0469
Propane	0.0782	0.0424	0.0710	0.0464	0.0602	0.0565
Isobutane	0.0255	0.0182	0.0214	0.0184	0.0153	0.0189
n-Butane	0.0614	0.0439	0.0504	0.0434	0.0339	0.0420
Isopentane	0.0283	0.0251	0.0225	0.0241	0.0142	0.0218
n-Pentane	0.0343	0.0304	0.0270	0.0289	0.0162	0.0249
Hexanes and heavier	0.4557	0.7679	0.3534	0.7168	0.2012	0.5854
Carbon dioxide	0.0020	0.0011	0.0037	0.0024	0.0060	0.0056
Average molecular weight	81.29		67.50		46.97	
Gas-oil ratio[a]	552		940		2,205	

Weight fraction trap gas	0.5335		0.6292		0.8111	
Component	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction
Methane	0.7148	0.3549	0.7470	0.4157	0.7922	0.5315
Ethane	0.0826	0.0768	0.0847	0.0884	0.0878	0.1104
Propane	0.0526	0.0717	0.0507	0.0776	0.0482	0.0888
Isobutane	0.0110	0.0197	0.0099	0.0200	0.0085	0.0206
n-Butane	0.0222	0.0400	0.0194	0.0392	0.0155	0.0377
Isopentane	0.0081	0.0182	0.0067	0.0168	0.0047	0.0141
n-Pentane	0.0085	0.0190	0.0067	0.0167	0.0041	0.0123
Hexanes and heavier	0.0927	0.3893	0.0668	0.3133	0.0304	0.1688
Carbon dioxide	0.0076	0.0104	0.0081	0.0123	0.0086	0.0158
Average molecular weight	32.30		28.82		23.91	
Gas-oil ratio[a]	5,361		7,393		14,440	

[a] Plant-product basis.

The definition of the "liquid formation volume" is analogous to that of the formation volume of the entire mixture. It is the ratio of the volume of the liquid phase of the mixture to the volume of the oil associated with that mixture, the measurement of the volumes being subject to the same

Company's well No. 54-3 in the Paloma field. The forged-steel sample containers were equipped with valve ports at both ends and were thoroughly purged by flushing with a large excess of the fluids to be sampled. The sample containers were filled to capacity at the pressure of the

TABLE 8.—*Volumetric Behavior of Experimentally Studied Mixtures*

WEIGHT FRACTION TRAP GAS, 0.0571. GAS-OIL RATIO, 552 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (1112)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (1410)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb (1675)[a]	Formation Volume[b]	Liquid Formation Volume
B.P.	0.02350	0.02350	1.264	1.264	0.02520	0.02520	1.355	1.355	0.02665	0.02665	1.433	1.433
400	0.05849	0.02100	3.146	1.129	0.07800		4.195		0.09508		5.114	
600	0.03879	0.02170	2.086	1.167	0.05170	0.02201	2.781	1.184	0.06260	0.02213	3.367	1.190
800	0.02973	0.02240	1.599	1.205	0.03931	0.02283	2.114	1.228	0.04684	0.02305	2.519	1.240
1,000	0.02515	0.02311	1.353	1.243	0.03234	0.02361	1.739	1.270	0.03765	0.02394	2.025	1.288
1,250	0.02343		1.260		0.02736	0.02460	1.471	1.323	0.03148	0.02500	1.693	1.345
1,500	0.02333		1.255		0.02514		1.352		0.02782	0.02601	1.496	1.399
1,750	0.02323		1.249		0.02501		1.345		0.02659		1.430	
2,000	0.02314		1.245		0.02488		1.338		0.02640		1.420	
2,250	0.02307		1.241		0.02477		1.332		0.02622		1.410	
2,500	0.02300		1.237		0.02466		1.326		0.02608		1.403	
2,750	0.02294		1.234		0.02457		1.321		0.02595		1.396	
3,000	0.02288		1.231		0.02448		1.317		0.02582		1.389	
3,500	0.02278		1.225		0.02431		1.307		0.02560		1.377	
4,000	0.02269		1.220		0.02417		1.300		0.02541		1.367	
4,500	0.02261		1.216		0.02403		1.292		0.02524		1.357	
5,000	0.02255		1.213		0.02390		1.285		0.02508		1.349	

WEIGHT FRACTION TRAP GAS, 0.1213. GAS-OIL RATIO, 940 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (1870)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (2210)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (2380)[a]	Formation Volume[b]	Liquid Formation Volume
B.P.	0.02522	0.02522	1.441	1.441	0.02768	0.02768	1.582	1.582	0.02971	0.02971	1.698	1.698
1,000	0.04020	0.02220	2.297	1.269	0.05275	0.02237	3.014	1.278	0.06117	0.02206	3.946	1.261
1,250	0.03295	0.02309	1.883	1.319	0.04275	0.02348	2.443	1.342	0.04954	0.02320	2.831	1.326
1,500	0.02862	0.02399	1.635	1.371	0.03662	0.02458	2.093	1.405	0.04215	0.02440	2.409	1.394
1,750	0.02579	0.02486	1.474	1.421	0.03242	0.02569	1.853	1.468	0.03707	0.02573	2.118	1.470
2,000	0.02517		1.438		0.02950	0.02679	1.686	1.531	0.03350	0.02720	1.914	1.554
2,250	0.02506		1.432		0.02766		1.581		0.03079	0.02883	1.759	1.647
2,500	0.02496		1.426		0.02746		1.569		0.02955		1.689	
2,750	0.02486		1.421		0.02728		1.559		0.02924		1.671	
3,000	0.02477		1.415		0.02711		1.549		0.02896		1.655	
3,500	0.02459		1.405		0.02680		1.531		0.02849		1.628	
4,000	0.02442		1.395		0.02652		1.515		0.02812		1.607	
4,500	0.02426		1.386		0.02629		1.502		0.02780		1.589	
5,000	0.02412		1.378		0.02608		1.490		0.02754		1.574	

[a] Figures in parentheses represent bubble-point pressures expressed in pounds per square inch absolute.
[b] Formation volume and gas-oil ratio are based upon the plant product.

TABLE 8.—(*Continued*)

WEIGHT FRACTION TRAP GAS, 0.2867. GAS-OIL RATIO, 2205 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (3430)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (3542)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (3595)[a]	Formation Volume[b]	Liquid Formation Volume
B.P.	0.02930	0.02930	1.996	1.996	0.03377	0.03377	2.300	2.300	0.03694	0.03694	2.516	2.516
1,000	0.0786	0.0178	5.35	1.21	0.1005	0.0163	6.85	1.11	0.1168	0.0162	7.96	1.10
1,250	0.0628	0.0185	4.28	1.26	0.0806	0.0169	5.49	1.15	0.0936	0.0164	6.38	1.12
1,500	0.0525	0.0193	3.58	1.31	0.0676	0.0176	4.61	1.20	0.0783	0.0167	5.33	1.14
1,750	0.0453	0.0200	3.09	1.36	0.0582	0.0183	3.96	1.25	0.0674	0.0169	4.59	1.15
2,000	0.0402	0.0208	2.74	1.42	0.0513	0.0190	3.49	1.29	0.0595	0.0172	4.05	1.17
2,250	0.0365	0.0216	2.49	1.47	0.0462	0.0198	3.15	1.35	0.0534	0.0175	3.64	1.19
2,500	0.0338	0.0224	2.30	1.53	0.0425	0.0206	2.90	1.40	0.0488	0.0180	3.32	1.23
2,750	0.0319	0.0233	2.17	1.59	0.0395	0.0216	2.69	1.47	0.0451	0.0186	3.07	1.27
3,000	0.0306	0.0243	2.08	1.66	0.0374	0.0229	2.55	1.56	0.0421	0.0194	2.87	1.32
3,500	0.02923		1.991		0.0345	0.0290	2.35	1.98	0.0376	0.0248	2.56	1.69
4,000	0.02878		1.961		0.03300		2.248		0.03528		2.403	
4,500	0.02843		1.937		0.03230		2.200		0.03422		2.331	
5,000	0.02812		1.916		0.03168		2.158		0.03340		2.275	

WEIGHT FRACTION TRAP GAS, 0.5335. GAS-OIL RATIO, 5361 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4490)[c]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4590)[c]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4630)[c]	Formation Volume[b]	Liquid Formation Volume
R.D.P.	0.03702	0	3.535	0	0.04367	0	4.170	0	0.04909	0	4.688	0
1,000	0.1398	0.01229	13.35	1.174	0.1790	0.00955	17.09	0.912	0.2036	0.00813	19.44	0.776
1,250	0.1087	0.01291	10.38	1.233	0.1409	0.01005	13.45	0.960	0.1610	0.00830	15.37	0.793
1,500	0.0882	0.01345	8.42	1.284	0.1157	0.01050	11.05	1.003	0.1332	0.00846	12.72	0.808
1,750	0.0742	0.01389	7.09	1.326	0.0982	0.01088	9.38	1.039	0.1133	0.00860	10.82	0.821
2,000	0.0645	0.01421	6.16	1.357	0.0855	0.01117	8.16	1.067	0.0986	0.00875	9.42	0.836
2,250	0.0571	0.01440	5.45	1.375	0.0759	0.01139	7.25	1.088	0.0877	0.00885	8.37	0.845
2,500	0.0517	0.01432	4.94	1.367	0.0687	0.01144	6.56	1.092	0.0791	0.00887	7.55	0.847
2,750	0.0476	0.01399	4.55	1.336	0.0629	0.01141	6.01	1.090	0.0725	0.00870	6.92	0.831
3,000	0.0447	0.01320	4.27	1.260	0.0583	0.01125	5.57	1.074	0.0670	0.00840	6.40	0.802
3,500	0.0409	0.01016	3.91	0.970	0.0515	0.00980	4.92	0.936	0.0588	0.00691	5.61	0.660
4,000	0.0386	0.00552	3.69	0.527	0.0470	0.00615	4.49	0.587	0.0534	0.00433	5.10	0.413
4,500	0.0371		3.54		0.0441	0.00110	4.21	0.105	0.0500	0.00100	4.77	0.095
5,000	0.0362		3.46		0.0425		4.06		0.0476		4.55	

[a] Figures in parentheses represent bubble-point pressures expressed in pounds per square inch absolute.
[b] Formation volume and gas-oil ratio are based upon the plant product.
[c] Figures in parentheses represent retrograde dew-point pressures expressed in pounds per square inch absolute.

TABLE 8.—(*Continued*)

WEIGHT FRACTION TRAP GAS, 0.6292. GAS-OIL RATIO, 7393 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4560)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4730)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4780)[a]	Formation Volume[b]	Liquid Formation Volume
R.D.P.	0.04158	0	4.703	0	0.04888	0	5.529	0	0.05450	0	6.164	0
1,000	0.1620	0.01025	18.32	1.159	0.2081	0.00710	23.54	0.803	0.2339	0.00568	26.46	0.642
1,250	0.1248	0.01052	14.12	1.190	0.1625	0.00750	18.38	0.848	0.1846	0.00577	20.88	0.653
1,500	0.1010	0.01080	11.42	1.222	0.1327	0.00779	15.01	0.881	0.1523	0.00584	17.23	0.661
1,750	0.0849	0.01105	9.60	1.250	0.1122	0.00797	12.69	0.901	0.1294	0.00591	14.64	0.668
2,000	0.0736	0.01122	8.32	1.269	0.0975	0.00800	11.03	0.905	0.1127	0.00605	12.75	0.684
2,250	0.0652	0.01128	7.37	1.276	0.0864	0.00799	9.77	0.904	0.0999	0.00610	11.30	0.690
2,500	0.0589	0.01095	6.66	1.239	0.0778	0.00797	8.80	0.901	0.0902	0.00602	10.20	0.681
2,750	0.0543	0.01026	6.14	1.160	0.0711	0.00780	8.04	0.882	0.0826	0.00589	9.34	0.666
3,000	0.0507	0.00922	5.73	1.043	0.0659	0.00751	7.45	0.849	0.0765	0.00557	8.65	0.630
3,500	0.0460	0.00667	5.20	0.754	0.0582	0.00630	6.58	0.713	0.0673	0.00440	7.61	0.498
4,000	0.0433	0.00366	4.90	0.414	0.0531	0.00414	6.01	0.468	0.0611	0.00292	6.91	0.330
4,500	0.0417	0.00040	4.72	0.045	0.0499	0.00140	5.64	0.158	0.0565	0.00110	6.39	0.124
5,000	0.0406		4.59		0.0479		5.42		0.0531		6.01	

WEIGHT FRACTION TRAP GAS, 0.8111. GAS-OIL RATIO, 14,439 CUBIC FEET PER BARREL

Pressure, Lb. per Sq. In. Abs.	100°F.				190°F.				250°F.			
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (3835)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4305)[a]	Formation Volume[b]	Liquid Formation Volume	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4440)[a]	Formation Volume[b]	Liquid Formation Volume
R.D.P.	0.05241	0	9.130	0	0.06156	0	10.724	0	0.06901	0	12.022	0
1,000	0.2061	0.00593	35.90	1.033	0.2608	0.00288	45.43	0.502	0.2942	0.00190	51.25	0.331
1,250	0.1574	0.00567	27.42	0.988	0.2040	0.00282	35.54	0.491	0.2325	0.00186	40.50	0.324
1,500	0.1265	0.00527	22.04	0.918	0.1667	0.00273	29.04	0.476	0.1917	0.00180	33.40	0.314
1,750	0.1054	0.00474	18.36	0.826	0.1406	0.00260	24.49	0.453	0.1629	0.00172	28.38	0.300
2,000	0.0904	0.00415	15.75	0.723	0.1216	0.00244	21.18	0.425	0.1417	0.00161	24.69	0.280
2,250	0.0793	0.00357	13.81	0.622	0.1072	0.00224	18.68	0.390	0.1255	0.00148	21.86	0.258
2,500	0.0712	0.00300	12.40	0.523	0.0963	0.00200	16.78	0.348	0.1128	0.00135	19.65	0.235
2,750	0.0655	0.00243	11.41	0.423	0.0877	0.00175	15.28	0.305	0.1028	0.00121	17.91	0.211
3,000	0.0608	0.00187	10.59	0.326	0.0809	0.00148	14.09	0.258	0.0947	0.00106	16.50	0.185
3,500	0.0549	0.00075	9.56	0.131	0.0711	0.00092	12.39	0.160	0.0828	0.00070	14.42	0.122
4,000	0.0514		8.95		0.0646	0.00035	11.25	0.061	0.0746	0.00034	13.00	0.059
4,500	0.0490		8.54		0.0599		10.44		0.0684		11.92	
5,000	0.0473		8.24		0.0564		9.83		0.0636		11.08	

[a] Figures in parentheses represent retrograde dew-point pressures expressed in pounds per square inch absolute.
[b] Formation volume and gas-oil ratio are based upon the plant product.

primary separator and were carefully sealed. Upon arrival at the laboratory, the sample containers were tested and showed no sign of leakage.

TABLE 9.—*Properties of Bubble-point Liquid and Retrograde Dew-point Gas at Reservoir Temperature* 235°F.

Gas-oil Ratio[a] Cu. Ft. per Bbl.	Pressure, Lb. per Sq. In. Abs.	Formation Volume[a]	Specific Volume, Cu. Ft. per Lb.	Weight Fraction Trap Gas
243[b]	568	1.270	0.02485	0
500	1,430	1.416	0.02655	0.0479
1,000	2,430	1.711	0.02967	0.1306
1,500	3,010	2.020	0.03258	0.2017
2,000[c]	3,440	2.332	0.03515	0.2636
3,000	4,015	2.971	0.03961	0.3658
4,000	4,365	3.632	0.04340	0.4469
5,000[d]	4,570	4.306	0.04663	0.5127
6,000	4,690	4.993	0.04942	0.5672
8,000	4,785	6.398	0.05405	0.6523
10,000	4,765	7.876	0.05803	0.7156
12,500	4,620	9.910	0.06296	0.7751
15,000	4,320	12.401	0.06925	0.8203

[a] Plant-product basis.
[b] Trap liquid.
[c] For values of gas-oil ratio of 2000 cu. ft. per bbl. or less, the properties of the bubble-point liquid are given.
[d] For values of gas-oil ratio of 5000 cu. ft. per bbl. or more, the properties of the retrograde dew-point gas are given. Transition from bubble-point liquid to retrograde dew-point gas occurs somewhere in the interval of gas-oil ratios from 2000 to 5000 cu. ft. per barrel.

TABLE 10.—*Composition of Well-production Mixture*[a]

Component	Mol Fraction	Weight Fraction
Methane	0.7192	0.3625
Ethane	0.0828	0.0782
Propane	0.0523	0.0724
Isobutane	0.0108	0.0197
n-Butane	0.0219	0.0399
Isopentane	0.0079	0.0180
n-Pentane	0.0083	0.0187
Hexanes and heavier	0.0891	0.3800
Carbon dioxide	0.0077	0.0106
Average molecular weight	31.83	
Gas-oil ratio,[b] cu. ft. per bbl.	6777	
Gas-oil ratio,[c] cu. ft. per bbl.	5577	

[a] Corresponds to a mixture of the trap samples composed of 0.5453 weight fraction trap gas.
[b] Tank-oil basis.
[c] Plant-product basis.

The production conditions at the time of sampling are described in Table 1. It is understood that the well was producing under steady-state conditions so that it might reasonably be supposed that the mixture produced at the surface was representative of the fluid flowing into the well at the producing horizon.

A subsample of the trap gas was taken in the laboratory by withdrawing a portion of the primary gas sample through a drying chamber packed with granular calcium chloride into a low-pressure gas holder. Previous to the subsampling, the drying chamber and gas holder were evacuated, and the primary trap-gas container was raised to a temperature above 200°F., to ensure the vaporization of any condensate that might have appeared. In order to reduce the effect of selective adsorption of hydrocarbon components by the drying agent, a considerable amount of trap gas was flushed through the drier before the subsample was taken.

TABLE 11.—*Composition of Well-production Residue Gas and Plant-product Oil*

Component	Residue Gas Mol Fraction	Residue Gas Weight Fraction
Methane	0.8344	0.6922
Ethane	0.0960	0.1493
Propane	0.0607	0.1383
Carbon dioxide	0.0089	0.0202
Average molecular weight	19.34	

Component	Plant-product Oil Mol Fraction	Plant-product Oil Weigh Fraction
Isobutane	0.0783	0.0414
n-Butane	0.1584	0.0838
Isopentane	0.0576	0.0378
n-Pentane	0.0599	0.0393
Hexanes and heavier	0.6458	0.7977
Average molecular weight	109.9	
Gravity	58.8° A.P.I.	

A subsample of the trap liquid was removed from the primary container by displacement with ethylene glycol at a pressure in excess of 1000 lb. per sq. in. A considerable amount (approximately 10 times the volume of the subsample container) of the sample was flushed through the subsample container before the container was sealed.

The trap-gas and trap-liquid subsamples were shipped to a laboratory of the Union Oil Company of California, where the trap samples and a sample of the tank oil were analyzed by conventional low-temperature fractional distillation. The analyses of the trap samples are recorded in Table 2. The hexanes-and-heavier portion of the trap-liquid sample was separated into several cuts by high-temperature distillation. A number of the physical properties of the hexanes-and-heavier portion of the trap liquid and of the cuts are recorded in Table 3.

TABLE 12.—*Volumetric Behavior of Well-production Mixture at Reservoir Temperature* 235°F.

Pressure, Lb. per Sq. In. Abs.	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb.	Formation Volume	Liquid Formation Volume
4,648[a]	0.04829	0	4.701	0
1,000	0.2012	0.00820	19.59	0.798
1,250	0.1590	0.00842	15.48	0.820
1,500	0.1311	0.00865	12.76	0.842
1,750	0.1115	0.00890	10.86	0.866
2,000	0.0972	0.00905	9.46	0.881
2,250	0.0863	0.00915	8.40	0.891
2,500	0.0778	0.00920	7.57	0.896
2,750	0.0712	0.00912	6.93	0.888
3,000	0.0658	0.00890	6.41	0.866
3,500	0.0579	0.00760	5.64	0.740
4,000	0.0527	0.00480	5.13	0.467
4,500	0.0492	0.00115	4.79	0.112
5,000	0.0469		4.57	

[a] Retrograde dew point.

An analysis of the tank oil is given in Table 4. The sample used for this analysis doubtless suffered a slight loss of its more volatile components because it was shipped in a loosely stoppered container. However, it is estimated that the uncertainties from this source probably do not affect the reported values of gas-oil ratio and formation volume by more than 0.5 per cent. In computing the relative proportions of the trap samples that must be combined to yield a mixture corresponding to the well-production mixture, use was made of material-balance equations involving the analyses of the trap samples and tank oil and the reported production gas-oil ratio of the well. In these calculations it was assumed that the composition of the hexanes-and-heavier portion of the trap liquid is identical with that of the corresponding portion of the tank oil. While this assumption is not rigorously true, experience has shown that it introduces a negligible uncertainty into the results and greatly simplifies the calculations.

TABLE 13.—*Additional Sampling Conditions of Well Described in Table* 1

Date of sampling, May 26, 1942	
Tubing pressure, lb. per sq. in. abs.	3,165
Casing pressure, lb. per sq. in. abs.	2,795[a]
High-pressure separator:	
Pressure, lb. per sq. in. abs.	460
Temperature, deg. F.	71
Gas rate, cu. ft. per day	1,131,000[b]
Low-pressure separator:	
Pressure, lb. per sq. in. abs.	90
Temperature, deg. F.	62
Gas rate, cu. ft. per day	28,000
Vent tank:	
Pressure	Atmospheric
Gas rate, cu. ft. per day	12,000
Oil rate, bbl. per day	193.6
Gas-oil ratio, cu. ft. per bbl.	6,049[c]

[a] Presented as received in report from the field. Possibly the two should be interchanged.
[b] Measurements of gas and oil production rates have been reduced to standard conditions, 60°F. and 14.73 lb. per sq. in. absolute.
[c] Tank-oil basis.

LABORATORY APPROACH.

The equipment and techniques employed in work of this nature have been described in the literature,[8,9] and no fundamental modifications were necessary for the present investigation.

The volumetric behavior of the individual trap samples was determined as a preliminary to the investigation of a series of their mixtures. In Table 5 the compressibility factor of the trap gas is recorded at pressures up to 5000 lb. per sq. in. at 100°, 190°, and 250°F., which were the temperatures employed experimentally, and at 235°F., the reservoir temperature. The data at 235°F. were obtained from the experimental results by graphical interpolation with respect to temperature. For purposes satisfied by rough approximations, the volumetric properties of the trap gas may be used to represent the behavior of the gas phase existing in the reservoir. Calculations based upon recently published

equilibrium constants[10] indicate that at pressures up to 4000 lb. per sq. in. this approximation probably does not involve uncertainties greater than 10 per cent.

The quantities of the trap samples comprising the experimentally studied mixtures were determined gravimetrically by mercury displacement of the samples from weighed containers into the equilibrium cell of the volumetric apparatus. The detailed compositions of the experimentally studied mixtures computed from the data in Table 2 and the measured proportions of the trap samples in each mixture are presented in Table 7. The experimental data from the volumetric study of these mixtures at 100°, 190°, and 250°F. and at pressures up to 5000 lb. per sq. in. are recorded in Table 8. For convenience and uniformity in the tabulation, the data have been interpolated to even values of the pressure. However, as shown in Figs. 1 and 2, the original data points of pressure were distributed more or less at random.

TABLE 14.—*Composition of Trap Samples*

Component	Gas		Original Liquid		Modified Liquid[c]	
	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction
Methane	0.8479	0.6929	0.0931	0.0159		
Ethane	0.0801	0.1227	0.0740	0.0237		
Propane	0.0398	0.0894	0.1169	0.0549		
Isobutane	0.0059	0.0175	0.0386	0.0239		
n-Butane	0.0104	0.0308	0.0958	0.0593		
Isopentane	0.0023	0.0085	0.0433	0.0333	0.0052	0.0027
n-Pentane	0.0011	0.0040	0.0427	0.0328	0.0652	0.0341
Hexanes	0.0013	0.0056	0.0795	0.0730	0.1638	0.1023
Heptanes	0.0007	0.0036	0.1103	0.1177	0.1923	0.1396
Octanes and heavier	0.0004[a]	0.0024	0.3058[b]	0.5655	0.5735	0.7213
Carbon dioxide	0.0101	0.0226				
Average molecular weight	19.63		93.88		138.0	

[a] Estimated average molecular weight, 125.0.
[b] Average molecular weight determined from freezing-point lowering of benzene extrapolated to infinite dilution of the solute, 173.6.
[c] Trap-liquid sample modified by removal of all the butanes and lighter components and most of the isopentane.

In Table 6 the volumetric behavior of the trap-liquid sample is recorded for the experimentally studied temperatures at pressures up to 5000 lb. per sq. in. The observed bubble-point pressures are in satisfactory agreement with the reported pressure of the primary separator of the well at the time of sampling. This indicates that there was no appreciable leakage or deterioration of the sample during shipping and storage for several months.

The properties of the individual trap samples having been established, a series of mixtures of them was investigated. A system consisting of such a mixture may be regarded as a "pseudobinary" or a "restricted multicomponent system," because it comprises two multicomponent constituents whose compositions are fixed, and the possible variation in the composition of the system is restricted to that which can be produced by varying the proportions of the two constituents. As shown in Table 2, the range of gas-oil ratio possible in this system lies between 243 and 40,108 cu. ft. per barrel, expressed in terms of the plant product.

Experimental Results

With the completion of the laboratory measurements upon the experimental mixtures, an extensive graphical examination of the data was undertaken. Large-scale charts similar to those illustrated by Figs. 3 and 4 were constructed in order to correlate the volumetric and phase behavior with the composition of the system. By interpolation of the results with respect

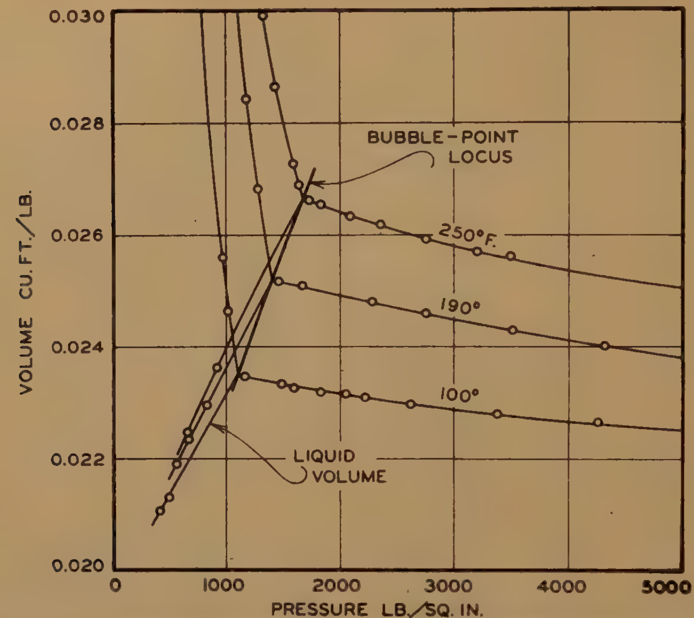

FIG. 1.—ILLUSTRATION OF EXPERIMENTAL PRECISION IN MEASUREMENT OF VOLUME FOR MIXTURE COMPOSED OF 0.0571 WEIGHT FRACTION TRAP GAS.

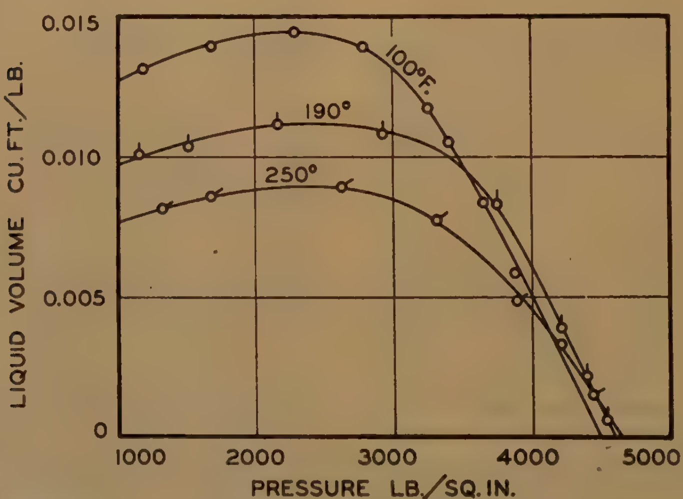

FIG. 2.—ILLUSTRATION OF EXPERIMENTAL PRECISION IN MEASUREMENT OF VOLUME OF LIQUID PHASE OF MIXTURE COMPOSED OF 0.5335 WEIGHT FRACTION TRAP GAS.

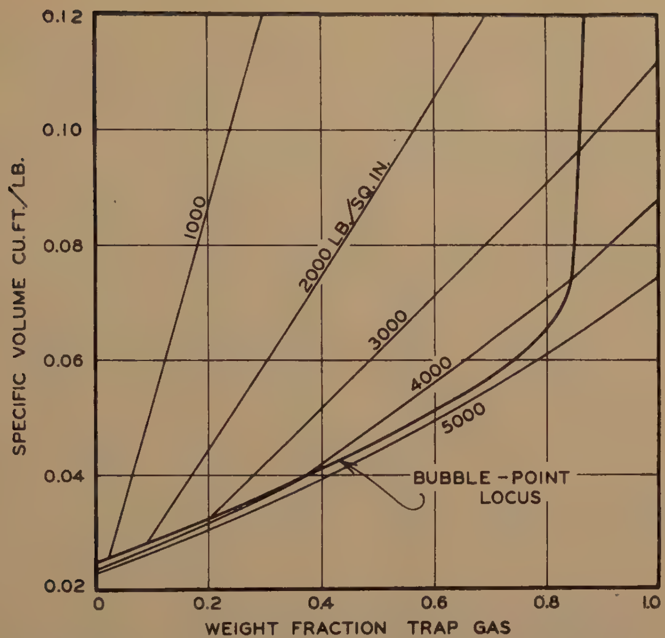

FIG. 3.—ISOBARIC RELATIONSHIPS BETWEEN SPECIFIC VOLUME AND COMPOSITION AT 235°F.

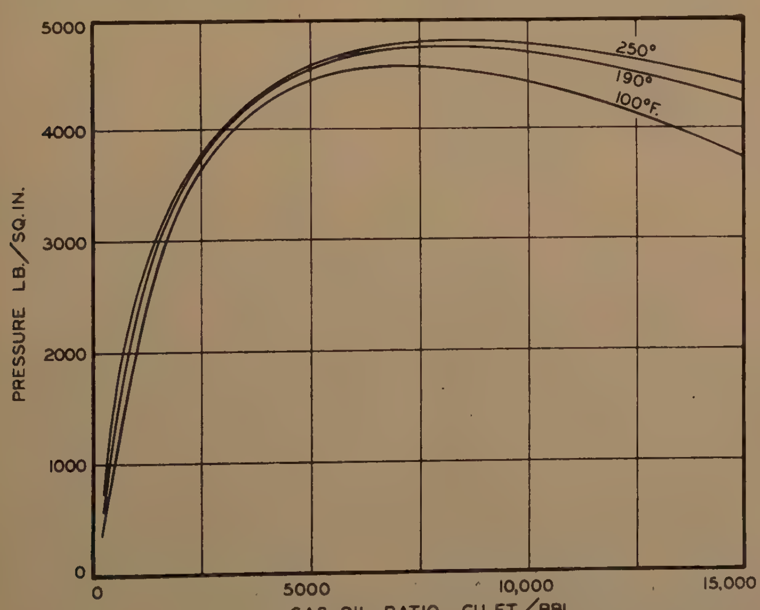

FIG. 4.—ISOTHERMAL RELATIONSHIPS BETWEEN BUBBLE-POINT AND RETROGRADE DEW-POINT PRESSURE AND GAS-OIL RATIO EXPRESSED IN TERMS OF PLANT PRODUCT.

to temperature, the behavior of the system was determined for 235°F., the reported temperature of the reservoir. In this manner the data in Table 9 describing the properties of the bubble-point liquid and of the retrograde dew-point gas at reservoir temperature were obtained.

TABLE 15.—*Composition of Tank Oil*[a]

Component	Mol Fraction	Weight Fraction
Methane		
Ethane		
Propane	0.0396	0.0142
Isobutane	0.0322	0.0152
n-Butane	0.0898	0.0424
Isopentane	0.0409	0.0240
n-Pentane	0.0435	0.0255
Hexanes	0.1193	0.0835
Heptanes	0.1676	0.1364
Octanes and heavier	0.4671[b]	0.6588
Average molecular weight	123.1	

[a] Gravity = 52.6°A.P.I.
[b] Assumed to be of the same composition as the octanes-and-heavier portion of the trap liquid.

The transition from the region of bubble points to that of retrograde dew points occurs at the critical state of the system. At 235°F. the critical pressure of the system is approximately 4200 lb. per sq. in., while the composition of the critical mixture is in the vicinity of 40 weight per cent trap gas, corresponding to a gas-oil ratio of about 3500 cu. ft. per bbl. in terms of the plant product. These values are merely rough guesses, because the density of experimental data in this region is not sufficient to permit an accurate determination of the critical state. Although an exhaustive study of the critical properties of the system would have been of considerable academic interest, it was decided that such an investigation was not essential to the primary objective of this work, which was to determine the volumetric properties of the well-production mixture at 235°F.

On the basis of the gas-oil ratio obtained by measuring rates of production of separator gas and tank oil at the time of sampling, the well-production mixture was found to be composed of a mixture of the trap samples containing 0.5453 weight fraction trap gas. The detailed analysis of this mixture is presented in Table 10. The gas-oil ratios computed upon both the tank-oil basis and the plant-product basis are included in the table. It is apparent that the two bases yield significantly different numerical values for the gas-oil ratio. In Table 11 the components of the well-production mixture are shown

TABLE 16.—*Composition of Well-production Mixture*[a]

Component	Mol Fraction	Weight Fraction	First Modification[b]		Second Modification[c]	
			Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction
Methane	0.7101	0.3429	0.7454	0.3758	0.7902	0.4078
Ethane	0.0790	0.0715	0.0830	0.0784	0.0879	0.0850
Propane	0.0539	0.0715	0.0566	0.0784		
Isobutane	0.0119	0.0208				
n-Butane	0.0260	0.0455				
Isopentane	0.0098	0.0213				
n-Pentane	0.0087	0.0189	0.0091	0.0207	0.0097	0.0225
Hexanes	0.0156	0.0405	0.0164	0.0444	0.0173	0.0482
Heptanes	0.0208	0.0626	0.0218	0.0686	0.0231	0.0744
Octanes and heavier	0.0560	0.2936	0.0591	0.3218	0.0626	0.3491
Carbon dioxide	0.0082	0.0109	0.0086	0.0119	0.0092	0.0130
Average molecular weight	32.22		31.82		31.08	
Gas-oil ratio, cu. ft. per bbl	6,049[d]					

[a] Corresponds to a mixture of the trap samples composed of 0.4829 weight fraction trap gas.
[b] Modification of the well-production mixture calculated from the analyses of the trap samples with isobutane, n-butane, and isopentane removed.
[c] Modification of the well-production mixture calculated from the analyses of the trap samples with propane, isobutane, n-butane, and isopentane removed.
[d] Tank-oil basis.

separated into the residue gas and plant-product oil in accordance with the plant-product basis of computing gas-oil ratio and formation volume. It should be realized that Table 11 applies only to the well-production mixture. Any other mixture of the trap samples would yield a residue gas and plant-product oil with compositions differing from those recorded in Table 11.

The final results of the foregoing calculations and graphical interpolations are recorded in Table 12. The volumetric behavior of the well-production mixture at reservoir temperature throughout the pressure interval from 1000 to 5000 lb. per sq. in. has been evaluated. Within the uncertainty of the experimental results, the retrograde dew-point pressure was found to be equal to the pressure believed to prevail in the vicinity of the well intake at the time of sampling. The volume of the liquid phase attains a maximum value in the neighborhood of 2500 lb. per sq. in., while the ratio of liquid volume to total volume for a given weight of mixture passes through a maximum value at approximately 3000 lb. per sq. in., at which point the mixture is volumetrically about 13.5 per cent liquid.

It is apparent that the entire procedure that has been described needs justification because the desired result might have been obtained more quickly and easily by making direct measurements upon the well-production mixture at 235°F. Several factors were influential in determining the procedure that was followed. The most important consideration was one of policy, involving what might be termed the secondary objective of the investigation. For more than 15 years, this laboratory has been engaged in gathering data of fundamental importance in establishing the general physical behavior of hydrocarbons. The efficient pursuit of a long-time experimental program of this nature requires adherence to a definite pattern of operations. A part of that pattern consists in making the experimental measurements at a series of systematically chosen temperatures. The particular temperatures employed in this study were members of an adopted series and were selected in the belief that they represented the minimum number of isotherms permitting satisfactory interpolation of the data to reservoir temperature and at the same time covering the range of temperature likely to be of interest to the production engineer.

TABLE 17.—*Composition of Experimentally Studied Mixtures*

Component	First Modification[a]		Second Modification[b]	
	Mol Fraction	Weight Fraction	Mol Fraction	Weight Fraction
Methane	0.7503	0.3814	0.7907	0.4079
Ethane	0.0814	0.0776	0.0877	0.0848
Propane	0.0554	0.0774		
Isobutane				
n-Butane				
Isopentane	0.0005	0.0012	0.0006	0.0013
n-Pentane	0.0076	0.0173	0.0081	0.0189
Hexanes	0.0177	0.0483	0.0191	0.0529
Heptanes	0.0201	0.0638	0.0217	0.0698
Octanes and heavier	0.0585	0.3212	0.0630	0.3515
Carbon dioxide	0.0085	0.0118	0.0091	0.0129
Average molecular weight	31.56		31.09	

[a] Experimentally modified mixture corresponding to the first modification of the well-production mixture given in Table 16.
[b] Experimentally modified mixture corresponding to the second modification of the well-production mixture given in Table 16.

It is true that only the well-production mixture is rigorously significant as far as actual production is concerned. All other mixtures of the trap samples must be regarded as approximations of possible well fluids, because, in general, a change in the well-production fluid would afford trap-gas and trap-liquid samples differing in composition from those used in this investigation. However, the study of the properties of mixtures differing from the well-production mixture yields data of very great practical value in estimating the future behavior of the well at various stages in the depletion of the reservoir.

Special Investigation of Modified Mixtures

About two years after the initial sampling of the well described in Table 1, another set of trap-gas and trap-liquid samples was taken from the same well. These samples were used in a study conducted under a special grant of funds by The Texas Company in the summer of 1942. A proposed plan to inject into the reservoir the residue-gas and natural-gasoline constituents remaining after the extraction of certain components of intermediate molecular weight required accurate information concerning the phase behavior of mixtures composed of these modified materials.

The production conditions at the time of the second sampling are given in Table 13. A comparison of the separator-gas and tank-oil production rates given in Tables 1 and 13 reveals a significant difference in the production gas-oil ratios. The change in the production gas-oil ratio based upon the tank oil might be attributed to changes in the separator conditions.

Table 18.—*Volumetric Behavior of Experimentally Studied Mixtures*

First Modification

Pressure, Lb. per Sq. In. Abs.	100°F.			190°F.			250°F.		
	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (4967)[a]	Compressibility Factor	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (5077)	Compressibility Factor	Specific Volume, Cu. Ft. per Lb.	Liquid Volume, Cu. Ft. per Lb. (5022)	Compressibility Factor
R.D.P.	0.03700	0	0.9657	0.04249	0	0.9765	0.04728	0	0.9840
200	0.8559		0.8995	1.0278		0.9305	1.1485		0.9519
400	0.3979		0.8364	0.4886		0.8847	0.5524		0.9157
600	0.2536	0.01022	0.7997	0.3151		0.8558	0.3583		0.8908
800	0.18431	0.01064	0.7748	0.23109	0.00937	0.8369	0.2636	0.00815	0.8738
1,000	0.14385	0.01104	0.7559	0.18216	0.00969	0.8246	0.20818	0.00847	0.8627
1,250	0.11217	0.01147	0.7368	0.14382	0.01003	0.8138	0.16478	0.00879	0.8536
1,500	0.09152	0.01185	0.7214	0.11871	0.01030	0.8061	0.13647	0.00903	0.8483
1,750	0.07730	0.01215	0.7108	0.10114	0.01052	0.8012	0.11654	0.00919	0.8452
2,000	0.06720	0.01236	0.7062	0.08817	0.01067	0.7983	0.10183	0.00928	0.8440
2,250	0.05980	0.01247	0.7070	0.07831	0.01075	0.7976	0.09057	0.00931	0.8445
2,500	0.05428	0.01245	0.7130	0.07080	0.01077	0.8012	0.08175	0.00928	0.8470
2,750	0.05012	0.01231	0.7243	0.06491	0.01069	0.8080	0.07476	0.00916	0.8520
3,000	0.04697	0.01205	0.7405	0.06016	0.01053	0.8170	0.06907	0.00896	0.8587
3,500	0.04273	0.01102	0.7858	0.05315	0.00986	0.8421	0.06055	0.00822	0.8783
4,000	0.04004	0.00906	0.8415	0.04840	0.00847	0.8764	0.05467	0.00675	0.9062
4,500	0.03820	0.00548	0.9034	0.04513	0.00561	0.9193	0.05048	0.00406	0.9413
5,000	0.03692		0.9700	0.04279	0.00085	0.9686	0.04739	0.00015	0.9820

Second Modification

		(5910)			(5815)			(5644)	
R.D.P.	0.03586	0	1.0970	0.04107	0	1.0650	0.04587	0	1.0570
200	0.8835		0.9148	1.0476		0.9344	1.1696		0.9550
400	0.4159		0.8613	0.5017		0.8950	0.5659		0.9241
600	0.2663		0.8273	0.3255		0.8710	0.3684		0.9025
800	0.19394	0.01074	0.8032	0.23973	0.00987	0.8553	0.2718		0.8876
1,000	0.15179	0.01097	0.7858	0.18959	0.01010	0.8455	0.21501	0.00910	0.8778
1,250	0.11901	0.01124	0.7701	0.15030	0.01037	0.8379	0.17071	0.00935	0.8712
1,500	0.09783	0.01148	0.7597	0.12455	0.01059	0.8332	0.14180	0.00958	0.8684
1,750	0.08314	0.01170	0.7532	0.10635	0.01078	0.8300	0.12135	0.00976	0.8674
2,000	0.07246	0.01188	0.7502	0.09292	0.01091	0.8288	0.10628	0.00989	0.8678
2,250	0.06447	0.01202	0.7510	0.08272	0.01101	0.8300	0.09469	0.00997	0.8698
2,500	0.05837	0.01210	0.7554	0.07475	0.01107	0.8334	0.08557	0.01002	0.8734
2,750	0.05368	0.01212	0.7642	0.06842	0.01108	0.8391	0.07827	0.01001	0.8788
3,000	0.05009	0.01208	0.7780	0.06336	0.01107	0.8477	0.07232	0.00994	0.8858
3,500	0.04512	0.01177	0.8175	0.05586	0.01082	0.8720	0.06329	0.00961	0.9044
4,000	0.04189	0.01109	0.8675	0.05064	0.01018	0.9033	0.05702	0.00884	0.9312
4,500	0.03958	0.00989	0.9220	0.04688	0.00903	0.9408	0.05246	0.00741	0.9638
5,000	0.03788	0.00794	0.9805	0.04415	0.00684	0.9845	0.04906	0.00502	1.0015
5,500	0.03667	0.00478	1.0440	0.04212	0.00303	1.0331	0.04649	0.00124	1.0440

[a] Figures in parentheses represent retrograde dew-point pressures expressed in pounds per square inch absolute.

However, the gas-oil ratio computed from the compositions of the well-production mixtures recorded in Tables 10 and 16, and expressed in terms of the plant product, are theoretically independent of separator conditions. The plant-product, well-production gas-oil ratios for the two sets of samples are respectively 5577 and 4913 cu. ft. per bbl. This indicates that in the interval of time between the two samplings an appreciable change has occurred in the nature of the fluid produced from the reservoir. It is possible that this change may be the result of entrainment of condensate that had accumulated in the vicinity of the well bore, though the plausibility of this suggestion is open to question.

Modified Mixtures

The analyses of the trap samples in terms of the weight fractions and mol fractions of the paraffinic components, from methane through heptane, were obtained by low-temperature fractional distillation. The results are recorded in Table 14. Included in the same table is the analysis of the modified liquid constituent obtained by the removal of most of the isopentane and all of the more volatile components from the trap-liquid sample. It would have been desirable to remove all of the isopentane from the modified liquid constituent, but the distillation apparatus used was not capable of effecting a complete separation of the pentanes.

The composition of the tank oil is given in Table 15. A comparison of this table with Table 4 shows that the tank oil obtained for the second set of samples contained a greater proportion of the more volatile components than did the earlier tank-oil sample. For the most part, probably this was the result of different separator conditions. The original communications reporting production conditions at the times of sampling indicate that the temperature of the vent tank in the first case was in the neighborhood of 100°F. while in the second case it was probably about 70°F.

The composition of the well-production mixture computed from the analyses of the trap samples is given in Table 16. The two desired modifications of this mixture are included in the table. The first modification involves the omission of isobutane, n-butane, and isopentane from the well-production mixture. The second modification omits propane as well as those components omitted in the first modification.

Table 19.—*Comparison of Retrograde Dew-point Pressures*

Pounds per Square Inch Absolute

Temperature, Deg. F.	Unmodified Mixture[a]	First Modification	Second Modification
100	4,388	4,967	5,910
190	4,460	5,077	5,815
235	4,487	5,045	5,695
250	4,500	5,022	5,644

[a] Determined from the experimental data given in Table 8 by graphical interpolation on the basis of a mixture composed of 0.4829 weight fraction trap gas.

Table 17 records the compositions of the mixtures experimentally studied. A comparison of these mixtures with the desired modifications of the well-production mixture described in Table 16 shows a reasonable correspondence in composition. The experimental mixtures were synthesized by adding suitable proportions of methane, ethane, propane, and carbon dioxide to the modified trap-liquid constituent described in Table 14.

Methane was obtained in a naturally pure state from the Bowerbank field, in the San Joaquin Valley, California. Analysis indicated traces of carbon dioxide and water as the only significant impurities. These were removed by passing the gas through an absorption chamber packed with alternate layers of sodium hydroxide pellets and granular calcium chloride at a pressure in excess of 1000 lb. per sq. in. It is estimated that the methane obtained in

this manner contained less than 0.001 mol fraction impurity.

Relatively impure ethane was obtained from the Carbide and Carbon Chemicals Corporation. This material was subjected to two low-temperature distillations with reflux ratios greater than 50 to 1. The initial and final 10 per cent portions distilled from the charge in the kettle of the column were discarded in each distillation. The middle fraction was condensed in vacuo at liquid-air temperatures with continuous removal of noncondensible gases by means of a Hivac pump during the condensation. The product of this process exhibited a vapor pressure that varied by less than 0.5 lb. per sq. in. upon vaporization of a sample from bubble point to dew point at 80°F. This was taken to be an indication of purity sufficient for the purposes of this investigation.

Chemically pure propane obtained from the Phillips Petroleum Co. and commercial carbon dioxide were used as received, without further purification.

Results of Tests on Modified Mixtures

The volumetric properties of the two experimentally studied, synthesized modifications of the well-production mixture are recorded in Table 17. Gas-oil ratios and formation volumes have not been computed for these mixtures because neither the tank-oil basis nor the plant-product basis as defined in the earlier part of this investigation is strictly applicable to them. The omission of certain components precludes the possibility of separating the mixtures into constituents comparable in composition to the tank oil or the plant product.

For purposes of comparison the retrograde dew-point pressures of the unmodified well-production mixture based upon the data presented in Table 8 and the retrograde dew-point pressures of the two modified mixtures are recorded in Table 19. The retrograde dew-point pressures for the modified mixtures were very much greater than those of the unmodified well-production mixture. The increase in retrograde dew-point pressure was more than

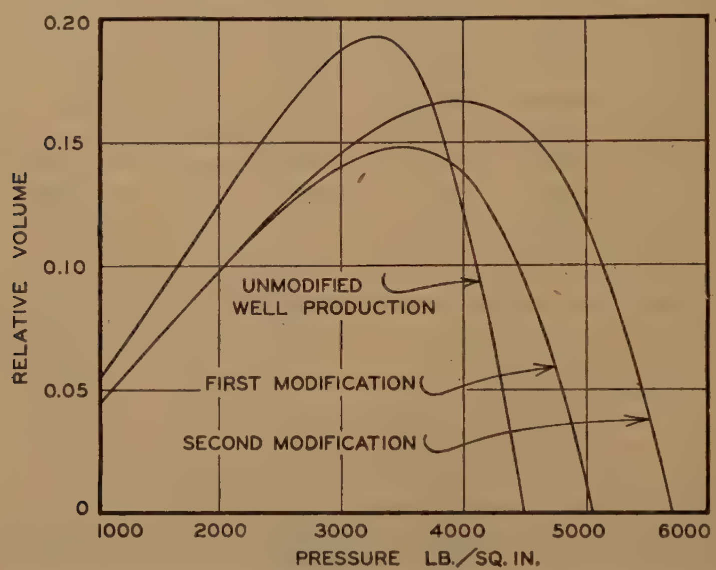

FIG. 5.—COMPARISON OF RELATIVE VOLUME OF UNMODIFIED AND TWO MODIFIED WELL-PRODUCTION MIXTURES AT 235°F.

two times as great for the case in which propane was among the extracted components as for the case in which propane was left in the mixture. A possible "explanation" of this phenomenon consists in regarding the components of intermediate molecular weight as solvents for the more and less volatile components of the mixture. This is in accord with an observed principle of chemistry that substances of similar kind are generally more miscible with one another than with dissimilar substances.

In any event the results were highly unfavorable to the proposed plan of operations because any attempt to inject either of the modified mixtures into the formation at reservoir pressure and temperature would result in a serious loss of a liquid material through condensation in the formation. An estimate of the magnitude of the condensation losses for the various cases may be obtained from Fig. 5, in which are shown the relative volumes—i.e., volume fractions of the mixtures occupied by the liquid phase—of the unmodified and the two modified well-production mixtures as functions of the pressure at 235°F. Fig. 5 shows that at 4500 lb. per sq. in. there is no liquid phase present in the unmodified well-production mixture while in the first and second modified mixtures at that pressure the liquid phases comprise, respectively, 9 per cent and 16 per cent of the total volumes of the mixtures.

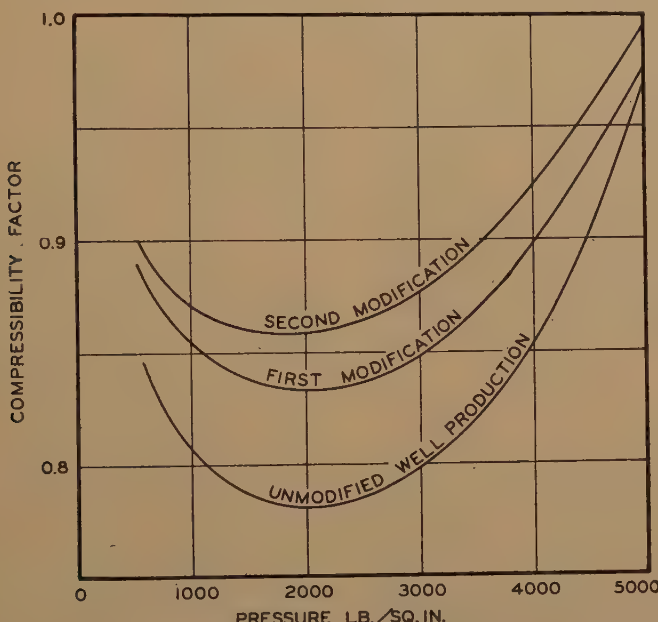

FIG. 6.—COMPARISON OF COMPRESSIBILITY FACTOR FOR UNMODIFIED AND TWO MODIFIED WELL-PRODUCTION MIXTURES AT 235°F.

The compressibility factors for the unmodified and the two modified well-production mixtures at 235°F. are graphically compared in Fig. 6. Since the average molecular weights of these mixtures are nearly equal, it is apparent from this figure that the presence of the components of intermediate molecular weight markedly increases the density of the mixture throughout the range of pressure involved in this study.

In addition to the effect upon the volumetric properties of the system, the extraction of components of intermediate molecular weight greatly reduced the rate at which equilibrium between phases was attained. In studying the two-phase region of the unmodified mixture, a 30-min. interval was found to be sufficient for the establishment of equilibrium after each change in state. For the modified mixtures, an interval of from one to two hours was required for the attainment of equilibrium. The experimental conditions for the two cases were identical, and so the difference in the rates of approach to equilibrium must be attributed to the differences in the compositions of the mixtures.

Experimental Precision and Accuracy

A distinction is made here in the meanings of the terms "precision" and "accuracy." The precision of a measurement depends upon the sensitivity of the measuring instrument and the skill of the person performing the measurement, whereas the accuracy of a measurement depends upon the reliability of the measuring instrument and the judgment of the person interpreting the measurement.

The precision of measurements performed in this experimental investigation is estimated to be as follows:

Pressure	0.1 lb. per sq. in.
Temperature	0.1°F.
Volume	0.1 per cent
Weight	0.01 per cent

The accuracy of the experimental observations is difficult to evaluate because so many factors influence the reliability of the final result. The experience gained from several year's operation of the laboratory equipment employed in this work leads to the following estimates of the uncertainties associated with the experimental results:

Single-phase pressure	0.2 per cent
Bubble-point pressure	1.0 per cent
Retrograde dew-point pressure	2.0 per cent
Temperature	0.5°F.
Volume	1.0 per cent
Weight	0.1 per cent

It should be realized that the probable errors associated with the measurements of production rates of gas and oil in the field are large compared with the uncertainties involved in the laboratory operations. Moreover, the practical limitations of analysis by fractional distillation affect the accuracy of the calculation of the proportion in which the trap samples must be mixed in order to reproduce the well-production mixture. In view of these sources of error, it is estimated that the computed composition of the well-production mixture and consequently the reported volumetric data pertaining to that mixture, may deviate from actuality by as much as 5 per cent.

The discrepancy in the relative magnitudes of the estimated precision and accuracy is due in part to random fluctuations in temperature in the course of an experimental measurement, to gradual changes in the calibrations of the instruments for measuring volume and pressure, and to the finite intervals of pressure and volume between the irregularly distributed experimentally observed equilibrium states, which necessitated interpolation and extrapolation of the data to the desired systematically distributed states.

Acknowledgments

This experimental work was made possible by the joint financial assistance of the Texaco Development Corporation and the General Petroleum Corporation. The authors express their gratitude to these corporations for their interest and cooperation. The assistance of Louise M. Reaney and J. A. Erwin in the calculations, and of L. T. Carmichael, J. V. Reynolds, and

H. A. Taylor in the experimental measurements is acknowledged.

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DISCUSSION

M. B. Standing.*—Messrs. Olds, Sage and Lacey have again presented a very complete and useful paper on the behavior of hydrocarbon mixtures. Of particular interest are the results of modifying the well-production mixture by the removal of various "key" components. Certainly, knowing that the removal of intermediate components from the well production would cause increased condensation losses if the residue fractions were then injected back into the sand is ample repayment for such a program.

There is, however, one point that I should like to bring up. While it is not concerned with the laboratory work as such, it is important because it is the basis upon which the laboratory work rests. The point is in regard to the operation of the well at the time of sampling.

Two sets of samples were obtained from the same well, the first on July 11, 1940 and the second May 26, 1942. The compositions of the well production at these two dates were not the same. If the field pressure had declined in the two-year interval, the second sample should have shown a higher gas-oil ratio (plant-production basis) than the first sample. Actually, the ratios were respectively 5577 and 4913 cu. ft. per barrel, which is opposite in direction from what they should have been.

In opposition to the authors' explanation that "this change may be the result of entrainment of condensate which had accumulated in the vicinity of the well bore," I should like to raise the question whether it might not be due to not getting true samples of the material being produced from the sands. The basis for this query is made clear by Table 20.

Using the data presented and assuming that the well is equipped with 2½-in. tubing, that the bottom-hole pressure is approximately 4700 lb. per sq. in. abs. and the flowing tubing-head temperature is 190°F., it can be calculated that the net rate of flow in the tubing varies from only 1.6 ft. per sec. to 2.5 ft. per sec. Flaitz and Parks[11] have stated that "stabilized flow can be maintained if linear velocities in the tubing are of the order of at least 15 to 20 ft.

Table 20

Date sampled	July 11, 1940	May 26, 1942
Formation pressure, lb. per sq. in. abs.	4,700	
Formation temperature, deg. F.	235	
Tubing pressure	2,295	3,165
Casing pressure	3,240	2,795
Flow rate:		
Gas, M cu. ft. per day	1,064	1,171
Oil, bbl per day	157	193.6
Gas-oil ratio, cu ft. per bbl.:		
Tank-oil basis	6,777	6,049
Plant-product basis	5,577	4,913
Production rate, lb. per day	98,350	119,200
Calculated flow rate in 2½ in. tubing, ft. per sec.:		
4700 lb. per sq. in. abs. and 235°F.	1.61	
3165 lb. per sq. in. abs. and 190°F.		1.96
2295 lb. per sq. in. abs. and 190°F.	2.54	

per sec." A. L. Vitter, Jr.,[12] in referring to tubing velocities, says that "linear velocities of 6 to 10 ft. per sec. are sufficient to give stabilized flow for back-pressure tests on wells with gas-oil ratios of approximately 25,000 cu. ft. per bbl." Also, "the smaller the ratio, the higher is the rate of flow necessary to ensure stabilized flow." From these two references it would seem that the rate of flow in the subject well is far below that necessary to give "stabilized" flow. In fact, at these low velocities of

* Standard Oil Company of California, La Habra, California.

[11] J. M. Flaitz and A. S. Parks: Sampling Gas-condensate Wells. *Trans.* A.I.M.E. (1942) **146**, 13.

[12] A. L. Vitter, Jr.: Back Pressure Tests on Gas-Condensate Wells. Amer. Petr. Inst. Drill. and Prod. Practice (1942) 79.

2 ft. per sec. it is questionable whether any condensate formed in the tubing by reduction of pressure and temperature would be produced from the well, unless the tubing were practically full of liquid.

During the first sampling period there was a difference in pressure of 945 lb. per sq. in. between the tubing and casing. This is too large to be explained as a flow loss, so it must be attributed to the presence of a bottom-hole choke or the existence of a high liquid level in the tubing—a high liquid level indicating accumulation of condensate.

The tubing and casing pressures were reversed during the second sampling period. Does this mean that the production was from the casing or that the liquid levels in the well caused this?

To summarize briefly; (1) The compositions of the well effluents on two different sampling dates did not check, and the difference was in a direction opposite to that expected; (2) the rates of flow in the tubing were so low that there is a question as to whether all of the material entering the tubing was produced; (3) field data presented on tubing and casing pressures and upon the well equipment and characteristics are not sufficient to disprove the contention that the compositional differences between the two samples was caused by the fluid conditions in the well at the time of sampling.

I believe that with a few more field data the points raised in this discussion could be settled.

E. W. McAllister.*—Mr. Standing points out that the difference in composition of the two samples taken at different periods for the laboratory experiments discussed in the paper was probably due to unstable flow conditions in the well tubing. His reason for this indicated that he did not acquaint himself with the mechanical conditions of the Paloma wells, nor is he familiar with the flow characteristics of the condensate wells in this field. The wells are equipped with 2-in. tubing—not 2½-in. This will increase the flow velocities, which he calculates, but not sufficiently to come within the range of those discussed in the article cited by Flaitz and Parks.

Flaitz and Parks discussed sampling of condensate wells by inserting a small vertical tube into the tubing at the well head. Under this arrangement of sampling it may be necessary to have the flow velocities given by Flaitz and Parks in order to obtain representative samples. In taking the Paloma samples the well was produced through separators and into a tank, from which equipment the gas and liquid samples were taken. From the gas charts it was indicated that the well was flowing under steady-state conditions; however, it is entirely possible that very minute heads of liquid were continually being made. While these might have influenced sampling conditions, as discussed by Flaitz and Parks, it is not believed that they were important in taking the Paloma samples, since the well rates were established over a 24-hr. period. In this respect the only way Flaitz and Parks could determine whether or not they were obtaining representative samples through the sampling device was by checking the liquid and gas produced through separators and into tanks, as was done in sampling at Paloma.

In regard to Mr. Standing's statement that condensing fluid probably falls back into the well as it is produced, there is no indication of this in any of the Paloma condensate wells. In the well sampled, subsurface pressure surveys do not indicate a fluid level, either under static or flow conditions. In flowing wells this is probably because of the density of the gas under the pressures involved, being nearly the same as that of the fluid condensed; also that the fluid, as it slowly condenses with pressure drop, is uniformly and finely dispersed throughout the gas and hence does not tend to fall back in the well, as would be expected in black-oil wells, but is carried in mist form to the surface.

Prior to the sampling of well 54-3 in July 1940 for the experiments at the California Institute of Technology, the well was on continuous production for approximately a year, producing more than 61,000 bbl. of condensate. This should have been ample time to stabilize the well or for it to fill with fluid, of which there was no indication. At times bottom-hole regulators were used in the well, which could account for certain differences in flowing pressures, as pointed out.

It is realized that this discussion does not explain the difference in the composition of the two samples; however, similar experiments run on separate samples taken at various times by

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a laboratory other than Cal-Tech, resulted in comparable condensation curves and dew-point determinations. While there were slight differences in these data, which to a research man might seem excessive, from a practical application of the data to developing the field, they are within a reasonable range; therefore, I do not believe the practical value of the experiments run by Cal-Tech has been in any way lessened because of the difference in composition of the two samples discussed. The authors are to be commended on a contribution of valuable data toward the development and production of the Paloma field.

Calculation of Static Pressure Gradients in Gas Wells

By M. J. Rzasa* and D. L. Katz,* Member A.I.M.E.

(New York Meeting, February 1945)

Abstract

The derivations of three methods of computing the static pressure gradients in natural gas wells have been presented to show the assumptions made. Charts were developed from which the pressure gradients may be read when the well-head pressure, the well fluid gravity, depth, and the average well temperature are given. A chart for estimating the well fluid gravity from the condensate content and separator gas gravity is included. The effect of the increased average well temperature after flow on the calculation of the static pressure gradient is discussed.

Introduction

Reservoir pressures have been calculated from well-head pressures for gas wells for many years. As the pressure measurements become more accurate, the need for a reliable calculation of the static pressure gradient often arises. This paper will develop the several methods for computing the pressure gradient in gas wells and make a comparison between them.

The method of calculating static pressure gradients in common use is Eq. 1 (ref. 1) or its counterpart which includes a factor for the deviation of the gas from the ideal gas law.

$$P_2 - P_1 = P_1(e^{0.0000347GX} - 1) \quad \text{Eq. [1]}$$

in which P_1 = pressure at well head, lb. per sq. in. abs.

P_2 = pressure at bottom of well, lb. per sq. in. abs.

G = gas gravity

X = depth of well, ft.

An alternate method is to compute the average density of the gas in the well and multiply by the well depth in a manner similar to that used for liquid gradients.

Derivation of Formulas

A static pressure gradient is a special case of the general fluid-flow equation. Consider a pound of fluid flowing in a vertical column from point 1 to point 2, Fig. 1. By an energy balance for fluid flowing from 1 to 2:

$$U_1 + P_1V_1 + \frac{u_1^2}{2g} + X_1 + q = U_2 + P_2V_2 + \frac{u_2^2}{2g} + X_2 + W \quad [2]$$

in which U = internal energy, ft-lb. per lb.

P = pressure, lb. per sq. ft.

V = volume, cu. ft. per lb.

u = average linear velocity, ft. per sec.

X = height above datum, ft.

q = heat absorbed by fluid, ft-lb. per lb.

W = work done by system, ft-lb. per lb.

An energy balance on the fluid itself gives:

$$U = \int TdS - \int PdV + \text{etc.} \quad [3]$$

in which T = temperature, deg. R.

S = entropy, ft-lb. per deg. R. per lb.

Manuscript received at the office of the Institute Nov. 6, 1944. Issued as T.P. 1814 in Petroleum Technology, March 1945.

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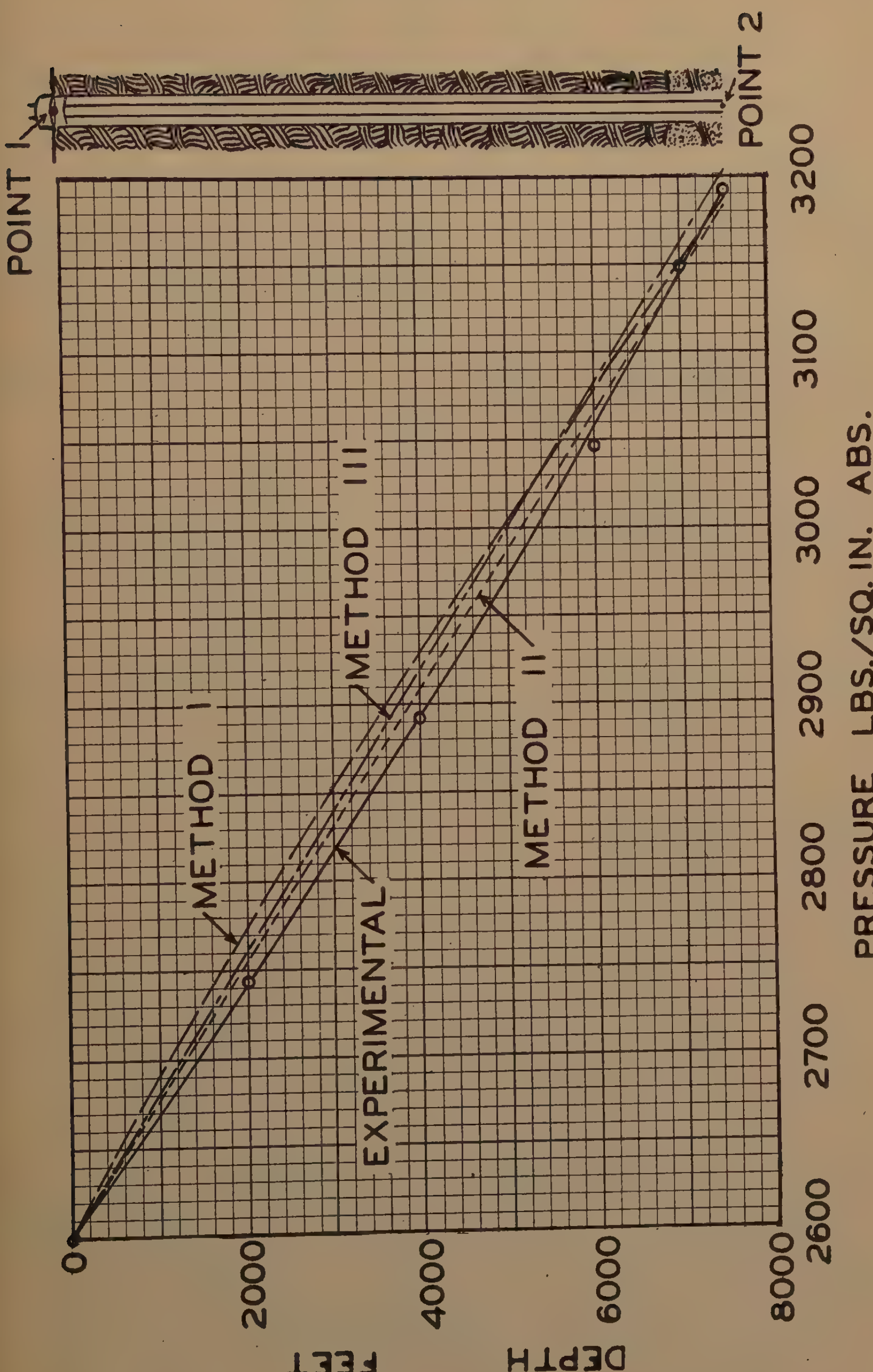

Fig. 1.—Depth-pressure gradient in gas well.

etc. = increase in all forms of energy other than heat and compression

If friction losses are defined as W_f, then

$$\int TdS = W_f + q \qquad [4]$$

A combination of Eqs. 2, 3, and 4 gives the general fluid-flow equation:

$$\int VdP + \frac{\Delta u^2}{2g} + \Delta X + W_f + W_s + \text{etc.} = 0 \qquad [5]$$

The limitations that may be placed on the general equation when considering a static or motionless column of fluid are:

u = 0. No velocity.
W_s = 0. No work done.
W_f = 0. No friction loss.
Etc. = 0. Energy other than heat and compression neglected.

With these limitations, Eq. 5 reduces to Eq. 6:

$$\int_1^2 VdP + \Delta X = 0 \qquad [6]$$

This equation gives the true pressure gradient as a function of the specific volume of the fluid throughout the well. If actual values of V were available throughout the well, the solution for P would be found such that the area under the curve of V versus P from P_1 to P_2 would equal the depth of the well X. In the absence of experimental values for V, the gas law and compressibility factor may be used to compute the specific volume.

$$PV = ZNRT \qquad [7]$$

in which P = pressure,
V = volume,
Z = compressibility factor,
N = number of mols per lb.,
R = gas constant per mol,
T = absolute temperature.

Combining Eqs. 6 and 7:

$$\int_1^2 \frac{ZNRT}{P} dP = X \qquad [8]$$

TABLE 1.—*Example Calculation for Method I*

$$\int_1^2 \frac{ZNRT}{P} dP = X \qquad [8]$$

Given: Well A
P_1 = 2600 lb. per sq. in. abs.,
Depth-temperature data,
X = 7500 ft.,
pP_c = 663.8 lb. per sq. inch,
pT_c = 385.6° R.,
G = 0.744

By approximate methods, or a series of trials on this method, the depth-pressure curve is obtained.

Depth, Ft., X	Well Pressure, P, Lb. per Sq. In. Abs.	Well Temperature, T, Deg. F.	T, Deg. R.	P_r	T_r	Z	$\frac{0.498ZT}{P}$	ΔP	$\frac{0.498ZT}{P}$ Av.	Area, Sq. Ft.	Cum. Area or X Calc.
0	2,600	77	537	3.92	1.39	0.701	0.0721				
1,000	2,691	110	570	4.05	1.48	0.765	0.0806	91	0.0764	1,000	1,000
2,000	2,774	144	604	4.18	1.56	0.807	0.0874	83	0.0839	1,002	2,002
3,000	2,852	159	619	4.30	1.61	0.829	0.0895	78	0.0887	996	2,998
4,000	2,929	174	634	4.41	1.64	0.[illegible]4[illegible]	0.0906	77	0.0900	998	3,996
5,000	3,005	190	650	4.52	1.69	0.861	0.0926	76	0.0916	1,002	4,998
6,000	3,079	206	666	4.64	1.73	0.880	0.0947	74	0.0936	998	5,996
7,000	3,152	221	681	4.75	1.77	0.894	0.0961	73	0.0953	1,000	6,996
7,500	3,188	228	688	4.80	1.79	0.901	0.0967	36	0.0963	500	7,496

$$N = \frac{1}{(0.744)(29.0)} = 0.0463$$

R = 10.73 $\qquad NR$ = 0.498

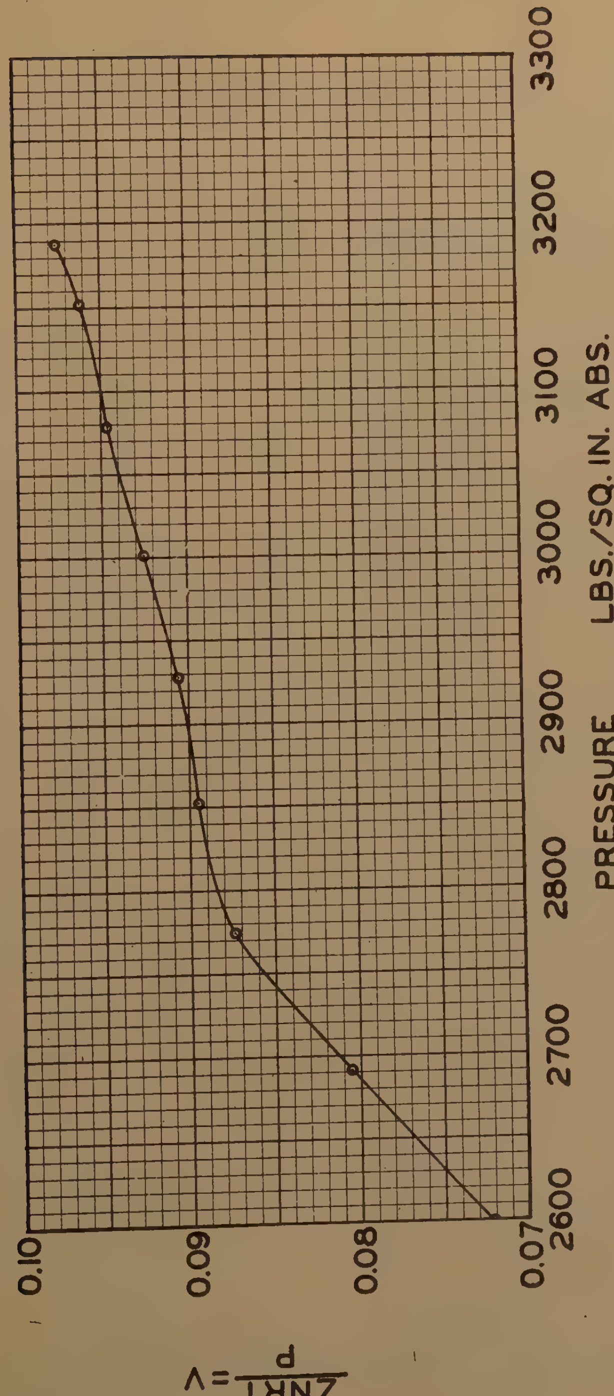

FIG. 2.—CURVE OF EQUATION 8.

Method I

In Eq. 8, R is constant and N is constant if the gas gravity is uniform throughout the well, but Z, T, and P are variables. To solve the integral, Z and T must be evaluated for each pressure. The solution for this method requires the desired pressure—gradient curve to evaluate Z and hence becomes a trial and error solution. Table 1 presents the final solution after a series of trials for the pressure gradient in a gas well using Eq. 8.

The data for well A from Eilerts and Schellhardt[2] were used for the measured static pressure and temperature gradient. The composition of the well fluid was given, which permitted calculation of its gravity G and the pseudocritical temperature pT_c and pressure pP_c.

The well pressures at each depth in Table 1 were estimated by prior calculations. The proof that they are correct lies in the calculation by Eq. 8 of the correct depth from the integral that is the area under the curve of Fig. 2.

Method II

An equation may be derived that has the form of Eq. 1 if T and Z are assumed constant and may be removed from the integral:

$$\int_1^2 \frac{ZNRT}{P}\,dP = Z_aNRT_a \int_1^2 \frac{dP}{P}$$

$$= Z_aNRT_a \ln\frac{P_2}{P_1} = X \quad [9]$$

Rearranging,

$$\ln\frac{P_2}{P_1} = \frac{X}{Z_aNRT_a}$$

or

$$P_2 - P_1 = P_1\left(e^{\frac{X}{Z_aNRT_a}} - 1\right) \quad [10]$$

TABLE 2.—*Example Calculation for Method II*

$$P_2 - P_1 = P_1\left(e^{\frac{0.01874GX}{T_aZ_a}} - 1\right) \quad [11]$$

Given: Well A

P_1 = 2600 lb. per sq. in. abs.
G = 0.744
X = 7500 ft.
T_a = 152.5° F. = 612.5° R.
pP_c = 663.8 lb. per sq. in. abs.
pT_c = 385.6° R.

First Trial
Assume

P_2 = 3100 lb. per sq. in. abs. P_a = 2850

$$P_r = \frac{2850}{663.8} = 4.30 \qquad T_r = \frac{61.5}{385.6} = 1.59$$

$$Z_a = 0.820$$

$$3100 - 2600 = 2600\left(e^{\frac{(0.01874)(0.744)(7500)}{(0.820)(612.5)}} - 1\right)$$

$$= 2600(e^{0.2082} - 1)$$

$$500 \neq 2600(0.2236) \neq 581 \text{ lb. per sq. in.}$$

Second Trial
Assume

P_2 = 3182 lb. per sq. in. abs. P_a = 2891

$$P_r = \frac{2897}{663.8} = 4.36 \qquad T_r = 1.59$$

$$Z_a = 0.821$$

$$3182 - 2600 = 2600\left(e^{\frac{(0.01874)(0.744)(7500)}{(0.821)(612.5)}} - 1\right)$$

$$= 2600(e^{0.2080} - 1)$$

$$582 = 2600(0.2239) = 582 \text{ lb. per sq. in.}$$

P_2 = 582 + 2600
= 3182 lb. per sq. in. abs. calculated by method II.
Measured pressure at 7500 ft.
= 3193 lb. per sq. in. abs

TABLE 3.—*Example Calculation for Method III*

$$\Delta P\left(1 - 0.00937\frac{XG}{T_aZ_a}\right) = 0.01874P_1\frac{XG}{T_aZ_a} \quad [13b]$$

Given: Well A

P_1 = 2600 lb. per sq. in. abs.
G = 0.744
X = 7500 ft.
T_a = 152.5°F. = 612.5°R.
pP_c = 663.8 lb. per sq. in. abs.
pT_c = 385.6°R.

First Trial
Assume

P_2 = 3100 lb. per sq. in. abs.
P_a = 2850 lb. per sq. in. abs.

$$P_r = \frac{2850}{663.8} = 4.30 \qquad T_r = \frac{617.5}{385.6} = 1.59$$

$$Z_a = 0.820$$

$$\frac{XG}{T_aZ_a} = \frac{(7500)(0.744)}{(612.5)(0.820)} = 10.10$$

$$\Delta P(1 - (0.00937)(110.10)) = (0.01874)(110.10)(2600)$$

$$0.8960\,\Delta P = 541$$

$$\Delta P = 604 \text{ lb. per sq. in.}$$

Second Trial, since Z_a taken at incorrect P_a
Assume

P_2 = 3204 lb. per sq. in. abs.
P_a = 2902 lb. per sq. in. abs.

$$P_r = \frac{2902}{663.8} = 4.37 \qquad T_r = 1.59$$

$$Z_a = 0.821$$

$$\frac{XG}{T_aZ_a} = \frac{(7500)(0.744)}{(612.5)(0.821)} = 110.09$$

$$\Delta P(1 - (0.00937)(110.09)) = (0.01874)(110.09)(2600)$$

$$0.8961\,\Delta P = 540.0$$

$$\Delta P = 602 \text{ lb. per sq. in.}$$

P_2 = 602 + 2600
= 3202 lb. per sq. in. abs. calculated by method III.
Measured pressure at 7500 ft.
= 3193 lb. per sq. in. abs.

This equation may be simplified, since $G = \frac{1}{29.0N}$ for one pound of fluid considered, and $R = 1544$ with P in units of pounds per square inch

$$P_2 - P_1 = P_1(e^{0.01874\frac{GX}{Z_a T_a}} - 1) \quad [11$$

Table 2 gives an example calculation of this method, using the same data as Table 1. This equation must be solved by trial and error for Z_a since it depends on an assumed average pressure.

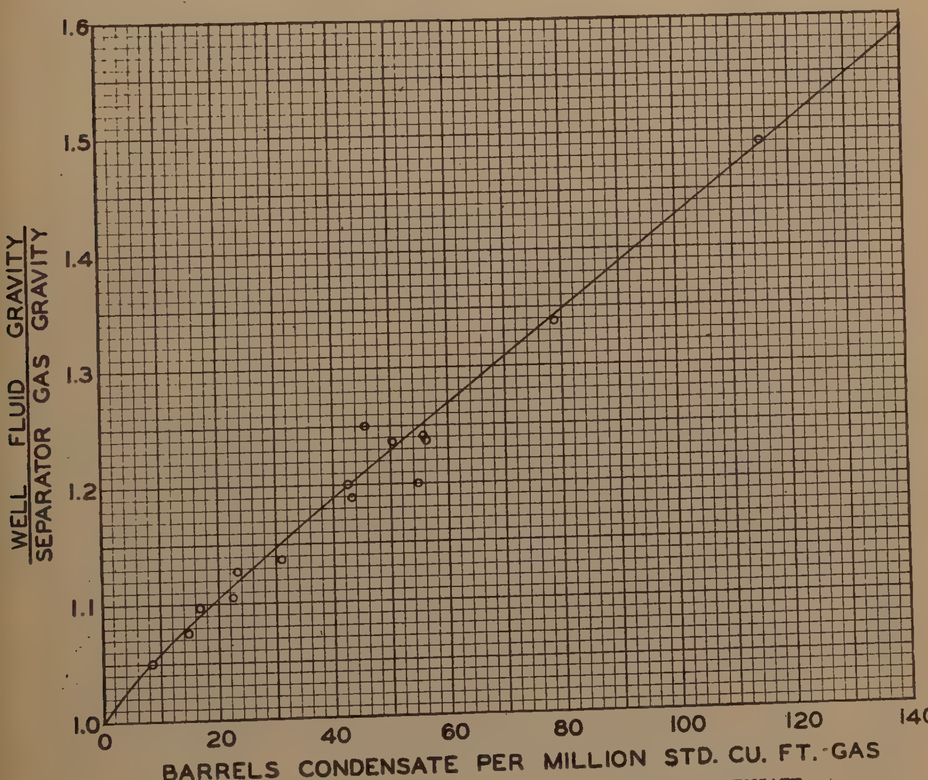

FIG. 3.—GRAVITY RATIO VERSUS STOCK-TANK YIELD OF CONDENSATE.

Method III

If the temperature and compressibility factor are assumed constant, it should make little difference to assume the pressure constant or to use an average value of V in Eq. 6.

$$\int_1^2 VdP = V_a \int_1^2 dP = V_a(P_2 - P_1) = \frac{P_2 - P_1}{\rho_a} = X \quad [12$$

in which ρ_a is the density of the fluid at the average pressure. Since ρ_a may be obtained by use of the compressibility factor, gas gravity, temperature, and pressure, the following equation results:

$$\frac{144(P_2 - P_1) \times 359 \times T_a \times 14.7 \times Z_a}{29.0 \times G \times 492 \times (P_1 + \Delta P/2)} = X \quad [13]$$

in which P represents units of pounds per square inch,

$$\Delta P = P_2 - P_1$$

$$\frac{\Delta P \times 29.0 \times 492 \times (P_1 + \Delta P/2) \times G \times X}{144 \times 359 \times 14.7 \times T_a \times Z_a} = \frac{0.01874(P_1 + \Delta P/2) \times G \times X}{T_a \times Z_a}$$

$$\Delta P = 0.01874\, P_a \frac{XG}{T_a Z_a} \qquad [13a]$$

$$\Delta P = 0.01874 \frac{P_1 XG}{T_a Z_a} + 0.00937 \frac{\Delta P XG}{T_a Z_a}$$

$$\Delta P \left(1 - 0.00937 \frac{XG}{T_a Z_a}\right) = 0.01874 \frac{XG}{T_a Z_a} P_1 \qquad [13b]$$

This equation is relatively easy to solve and involves a trial and error for the approximation is usually sufficient. If P, T, and Z are stright-line functions of depth, the equation is exact. If variations occur, the solution may be made for increments of depth with more accurate results.

Table 3 gives an example calculation for this method. The calculated bottom-hole pressures (lb. per sq. in. abs.) by the three methods are tabulated as follows:

Experimental Pressure[2]	Method I	Method II	Method III
3193	3188	3182	3202

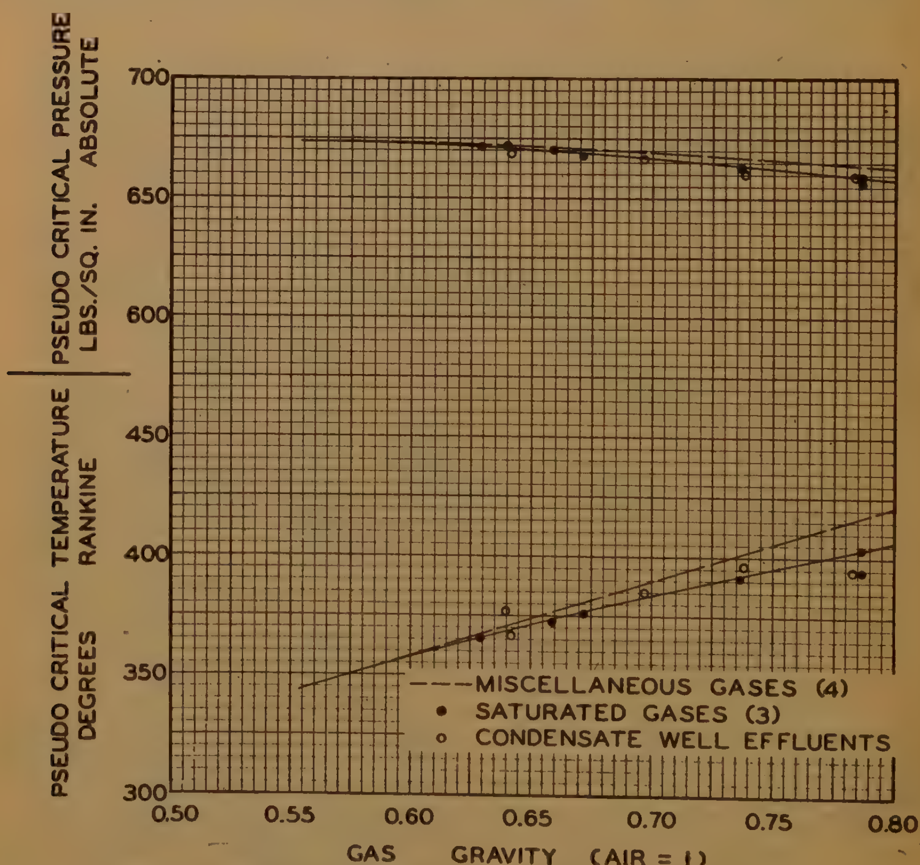

FIG. 4.—PSEUDOCRITICAL CONDITIONS AS FUNCTIONS OF GAS GRAVITY.

compressibility factor Z_a. However, the change in Z_a with pressure at the usual well conditions is not large and a second

The results indicate that the simpler methods II and III are essentially equivalent.*

* See Addendum.

Gravity of Well Fluids

A dry gas well producing no condensate will have the same gas gravity in the well as at the gas meter and presents no problem in finding the correct gravity. The gas composition in a well that produces condensate may be computed by adding the condensate to the gas separated. If the well fluid were a single phase throughout the well, the molecular weight of the well effluent gives the true gas gravity for the static column. When condensation takes place within the well bore due to temperature and pressure changes, the gas gravity G becomes a variable and N in Eqs. 8 through 10 is also a variable. Since the procedure for predicting the quantity of condensate and gas-phase composition in a well would be very complicated, either the well-effluent gravity or an average gravity for the well-fluid gas phase will be used.

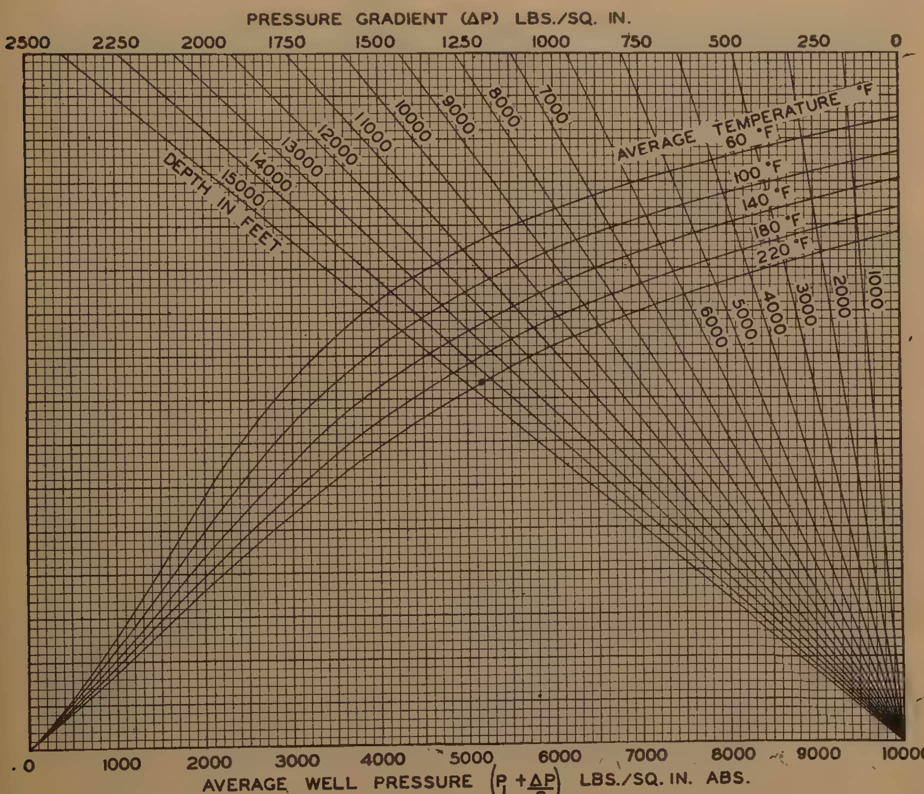

Fig. 5.—Pressure gradient as a function of average well pressure and temperature for 0.60 gravity gas.

A simple procedure for estimating the well fluid gravity is desired. The information normally available for a condensate well is the condensate yield in barrels of stock-tank liquid per million cubic foot of separator gas and the metered gas gravity. Fig. 3 has been prepared using actual data on 15 condensate wells for which the well effluent and separator-gas compositions were known in addition to the stock-tank yield of condensate. The curve appears to be of fairly general application, even though there are three vari-

ables, separator pressure, liquid gravity, and liquid molecular weight, which could cause different gravity ratios for a given stock-tank yield of condensate. The 15 condensate wells include a wide variety of all three of these variables, with no large net deviation from a single curve.

Pseudocritical Conditions

In addition to the well fluid gravity, the pseudocritical conditions must be known to predict the compressibility factor for any pressure-gradient calculation. If well effluent analyses are known, the pseudocritical conditions may be computed directly as molal average critical temperatures and pressures for the pure constituents. It has been shown that pseudocritical temperatures and pressures are a function of gas gravity for natural gases. Saturated gases at high pressure or condensate well effluents would have slightly different curves of gas gravity versus pseudocritical temperature and pressure than single-phase natural gases at low pressure.

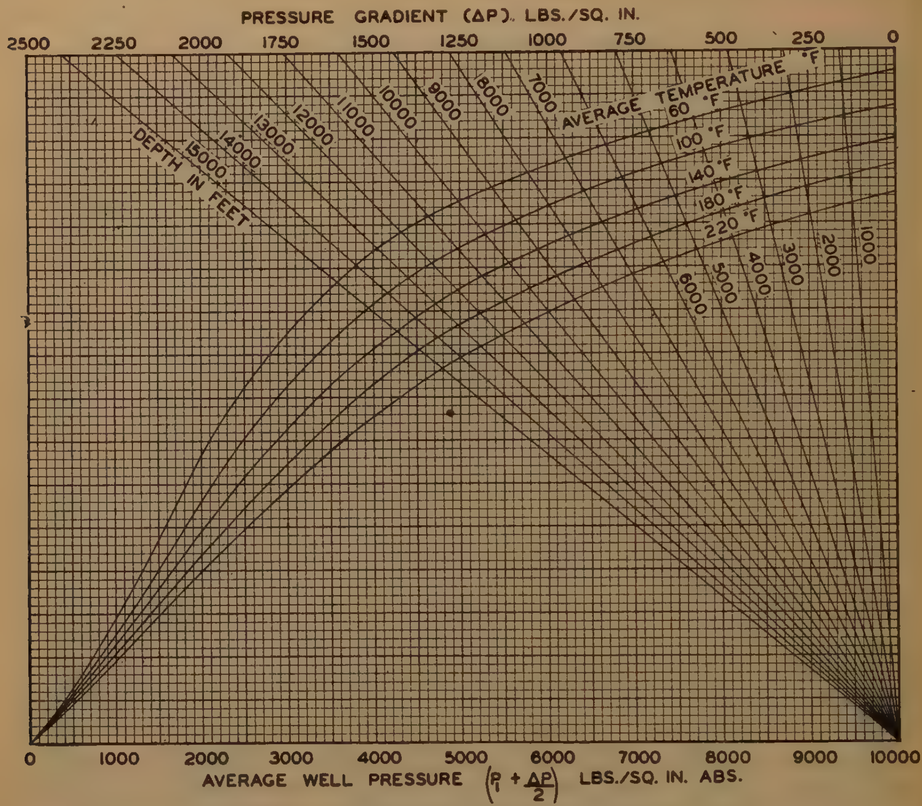

Fig. 6.—Pressure gradient as a function of average well pressure and temperature for 0.65 gravity gas.

Fig. 4 gives the pseudocritical conditions for saturated gases[3] and condensate well effluents. The curve developed for miscellaneous natural gases[4] is also shown.

Charts for Calculating Gradients

Since any well having a fixed well-head pressure, gas gravity, and well temperatures will have a definite static pressure gradient, it would seem that charts could

be developed to give the gradient as a function of well-head pressure P_1, average temperature T_a, gas gravity G, and depth X. By Eq. 13*b*, ΔP is a function of average pressure P_a, depth X, gas gravity G, and average temperature T_a, as Z_a is a dependent variable.

Figs. 5 through 9 have been prepared using Eq. 13*b* for gases of gravities 0.60, 0.65, 0.70, 0.75, and 0.80 with ΔP a function of depth at the average pressure and the average temperature in the well. These gases are assumed to follow the pseudocritical conditions of Fig. 4 and to have compressibility factors of references 3 and 4. The ordinates on these charts represent the density of the well fluid but on an odd scale to make the depth lines straight. Since the average pressure in a well is not known, a trial and error solution is involved when computing the bottom-hole pressure P_2 from the well-head pressure P_1.

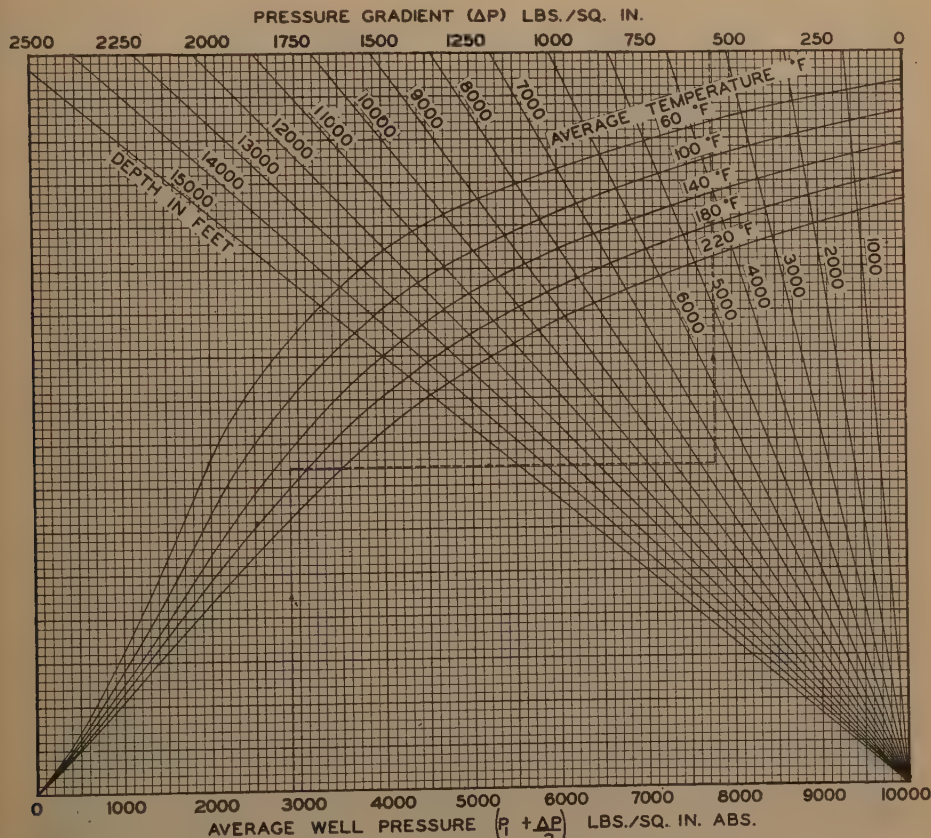

FIG. 7.—PRESSURE GRADIENT AS A FUNCTION OF AVERAGE WELL PRESSURE AND TEMPERATURE FOR 0.70 GRAVITY GAS.

To assist in this calculation, Fig. 10 has been prepared. The chart gives the pressure gradient ΔP for gases of 0.70 gravity, using a different average temperature for each depth. The depth-temperature relationship used is 133°F. at 4000 ft., 208°F. at 8000 ft., and 282°F. at 12,000 ft. For wells that have this temperature gradient and a well fluid gravity of 0.70,

Fig. 10 gives an accurate calculated gradient. For wells having different temperatures or gas gravities, Fig. 10 should be used only to approximate the ΔP in order to obtain the average pressure $(P_1 + \Delta P/2) = P_a$ in the well, which in turn is used in Figs. 5 through 9.

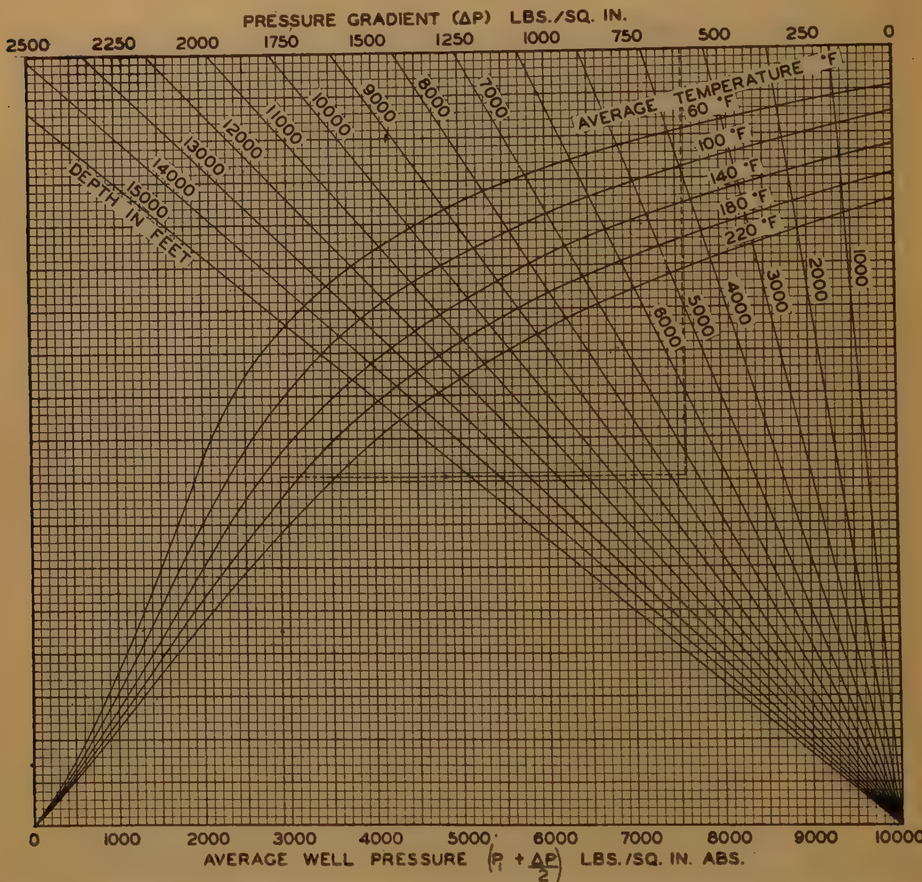

FIG. 8.—PRESSURE GRADIENT AS A FUNCTION OF AVERAGE WELL PRESSURE AND TEMPERATURE FOR 0.75 GRAVITY GAS.

EXAMPLE USES OF CHARTS

Using the data on well A, compute the pressure at 7500 ft. for a well having a tubing-head pressure of 2585 lb. per sq. in. gauge. The well fluid gravity is 0.744 and the average well temperature is 153°F.

By Fig. 10, the approximate gradient corresponding to 2600 lb. per sq. in. abs. is 610 lb. per sq. in. and P_a = 2905 lb. per sq. in. abs. From Figs. 7 and 8,

ΔP for 0.70 gravity gas = 565 lb. per sq. in.

ΔP for 0.75 gravity gas = 615 lb. per sq. in.

Interpolating for 0.744 gravity, ΔP = 609 lb. per sq. in.

P_2 at 7500 ft. = 3209 lb. per sq. in. abs.

Experimental value = 3193 lb. per sq. in. abs.

As a second example, compute the reservoir pressure at 8000 ft. for a well producing 40 bbl. of stock-tank condensate per million standard cubic feet of gas. The well-head pressure is 2800 lb. per sq. in. gauge, the separator-gas gravity is 0.670, and the temperature of the well bore at 4000 ft. is 135°F.

From Fig. 3, the well fluid gravity is estimated to be 1.19 × 0.670 = 0.789.

From Fig. 10, the approximate gradient corresponding to 2815 lb. per sq. in. abs. is 765 lb. per sq. in. and P_a = 3198 lb. per sq. in. absolute.

From Fig. 9 at 135°F. and 8000 ft., ΔP = 820 lb. per sq. in.

Repeating at P_a of 3225 lb. per sq. in. abs., ΔP = 825 lb. per sq. in.

Reservoir pressure = 2815 + 825 = 3640 lb. per sq. in. absolute.

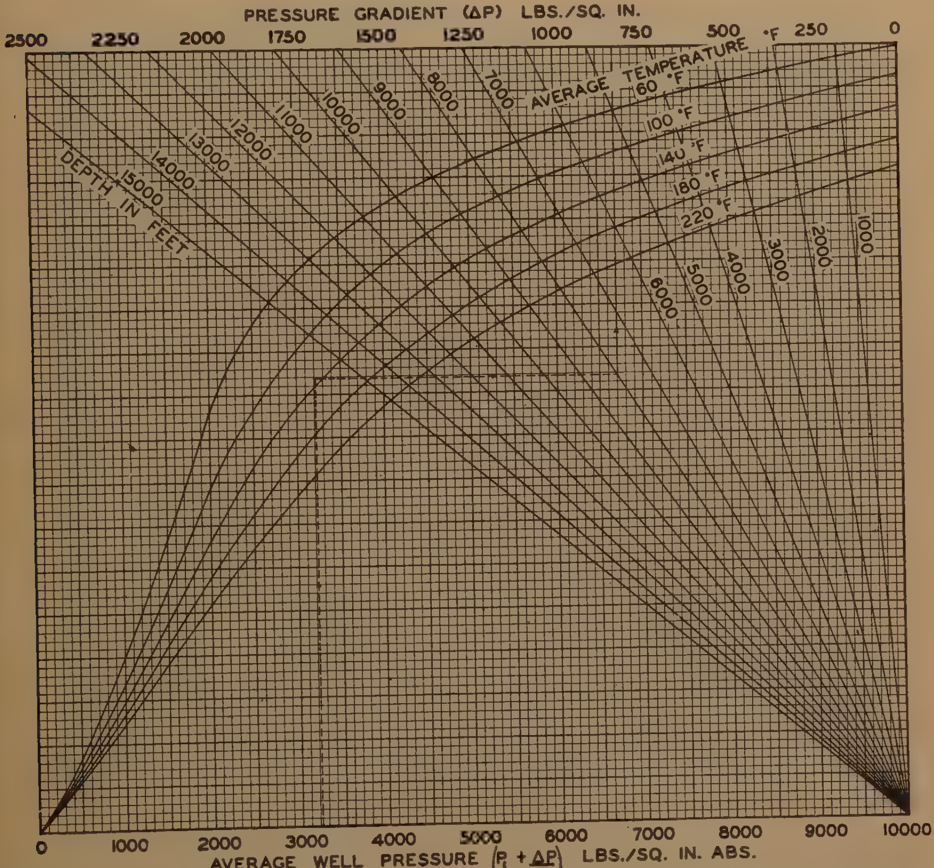

FIG. 9.—PRESSURE GRADIENT AS A FUNCTION OF AVERAGE WELL PRESSURE AND TEMPERATURE FOR 0.80 GRAVITY GAS.

EFFECT OF FLOW ON EARTH-TEMPERATURE GRADIENT

In estimating the average well temperature, the usual procedure is to assume a straight-line relationship between the reservoir temperature and a well-head temperature of 60° to 70°F., depending upon the

locality. If the well bore is in thermal equilibrium with the earth, this procedure gives results little different from the measured temperature gradient.

average well temperature from well history and flowing well-head temperature.

The effect of a change in the average well temperature due to heat transfer

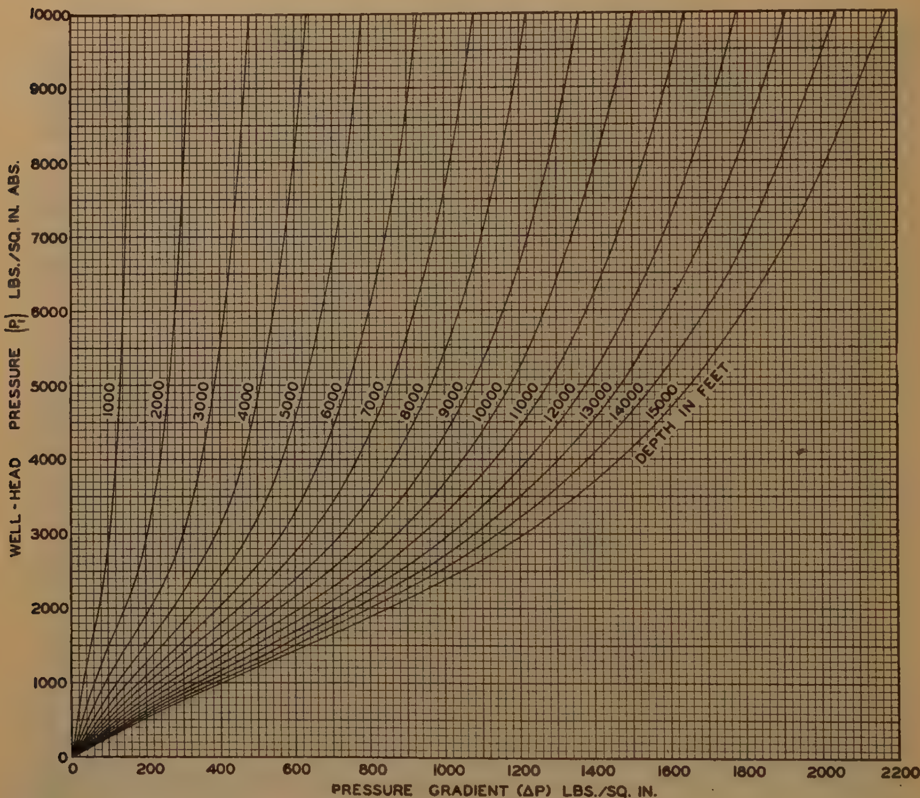

FIG. 10.—PRESSURE GRADIENTS FOR 0.70 GRAVITY GAS AND GIVEN EARTH-TEMPERATURE GRADIENT.

During flow, the well bore and surrounding earth gradually increase in temperature over the normal earth gradient. Harbert, Cain, and Huntington[5] have indicated the nature of this problem by laboratory measurements. A well that has been flowing prior to measurement of the well-head pressure will have a higher average well temperature than at thermal equilibrium. Further refinements in the calculation of pressure gradients in gas wells that have been flowing just prior to measurement of well-head pressure will include some procedure for estimating the

from the natural gas may be shown by using higher average temperatures for well A. For a well-head pressure of 2600 lb. per sq. in. abs., a gas gravity of 0.744 and a reservoir temperature of 228°F., the following values for ΔP

Assumed Surface Temperature, Deg. F.	Average Well Temperature, Deg. F.	ΔP from Figs. 7 and 8
77	152.5	609
97	162.5	589
117	172.5	574
137	182.5	555
157	192.5	535
177	202.5	520

are found by interpolating between Figs. 7 and 8 for a series of well temperatures.

These results indicate that the calculation of pressure gradients in gas wells that have been shut in only 24 hr. after a period of flow may not be accurate if the equilibrium earth-temperature gradient is used.

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Addendum

A more accurate comparison of methods II and III may be made by comparing the factors by which P_1 is multiplied to give $P_2 - P_1$. Let $0.01874 \dfrac{XG}{T_a Z_a} = c$, then for method II the factor becomes $(e^c - 1)$ and for method III it becomes $\left(\dfrac{c}{1 - 0.5c}\right)$. A direct comparison of the two factors for several values of c are as follows:

c	$(e^c - 1)$	$\dfrac{c}{1 - 0.5c}$
0.05	0.0513	0.0513
0.10	0.1052	0.1052
0.20	0.221	0.2222
0.30	0.350	0.353
0.40	0.492	0.500
0.50	0.649	0.667

These prove that the two methods should give practically identical results.

Measurement of Capillary Pressures in Small Core Samples

By G. L. Hassler,* Member A.I.M.E. and E. Brunner†

(Los Angeles Meeting, October 1944)

Abstract

An apparatus and method is described whereby the relation between saturation and capillary pressure under decreasing saturation can be quickly determined for small core samples. The initially saturated core is centrifuged at increasing rates and the average saturation is measured at each rate with the aid of a stroboscope device. A theory and calculation procedure is given whereby the accelerations and saturation values can be converted into a true curve of capillary pressure versus saturation.

The present work differs from previously described use of the centrifuge to obtain capillary-pressure curves of core samples[3] in that the core is centrifuged alone, so that the whole range of saturations required by the properties of the sample and the radially varying centrifugal force occurs within the sample. The calculation procedure nevertheless secures correct results from simply obtained values of the average saturation.

The apparatus described was developed in connection with studies of capillary pressure and wetting of oil-field rocks, and the paper provides the apparatus background for a previous publication[1] dealing more fully with the uses and implications of the data in petroleum engineering. The method is applicable, however, to general combinations of immiscible fluids and porous or comminuted solids, and may be useful in other fields.

Introduction

The importance of capillary phenomena in determining the behavior of liquids in porous media has long been recognized. The concept of capillary pressure was early formulated, and in recent years discussions of the application of the laws of capillarity to oil field problems have appeared.[1–3] One reason why progress in the application of capillary phenomena to the solution of problems of reservoir mechanics has not been more rapid has been the lack of a satisfactory technique for measuring the capillary pressures in reservoir rocks. It is the principal purpose of this paper to describe a method by which the relation between capillary pressure and saturation can be determined for small consolidated core samples which have been extracted and resaturated.

Capillary Diaphragm

Perhaps the most direct way to measure the capillary pressure in a rock is to make piezometric contact with the wetting liquid through a diaphragm of porous material with high displacement pressure saturated with the liquid in question.[3–6] The liquid in the diaphragm assumes the pressure of the liquid in the core, which can then be measured with a manometer, while the atmospheric air is prevented by capillarity from entering the diaphragm and affecting the pressure measurements as long as the displacement pressure of the diaphragm is not exceeded. With an apparatus of the type illustrated schematically in Fig. 1, the relation between capillary pressure and saturation can be measured for a small core sample by starting with the core saturated 100 per cent, applying successively greater suctions

Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1817 in Petroleum Technology, March 1945.

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[3] References are at the end of the paper.

to the liquid in the capillary diaphragm, and determining the saturation of the core at each value of the suction by measuring the quantity of liquid that has been removed from the core when equilibrium has been attained. If a suction greater than the displacement pressure of the diaphragm is applied, air enters the diaphragm and brings the series of measurements to a close; if, however, the pressure on the liquid in the diaphragm is allowed to increase (the suction to decrease) before the diaphragm has broken down, liquid will flow into the core from the diaphragm and points on the imbibition branch of the capillary hysteresis loop[2,7] can be obtained.

It was with an apparatus of this type that measurements of capillary pressure in a core containing three phases (water, oil and air) published elsewhere[1] were obtained in this laboratory. A capillary diaphragm of diatomaceous earth was used to measure the pressure in the oil phase. This material is preferentially wet by water, but it was protected from contact with the water in the core by a thin layer of finely powdered graphite which was deposited on the diaphragm as a filter cake from a suspension in oil, and no trouble was experienced from water entering the diaphragm.

The use of a capillary diaphragm for measuring capillary pressures is very satisfactory in the region of low capillary pressure and correspondingly high saturation, but it is severely limited by the low displacement pressures of reasonably permeable diaphragms.

Gravity Drainage

The earliest measurements of capillary pressure[8] were made by allowing a column of sand saturated with liquid to come to equilibrium by gravity drainage and subsequently determining the saturation distribution in the column by cutting it into sections and separately measuring the saturation of each section. In equilibrium the pressure gradient in the liquid is determined by the density of the liquid and the acceleration of gravity so that if the level of the free liquid surface,

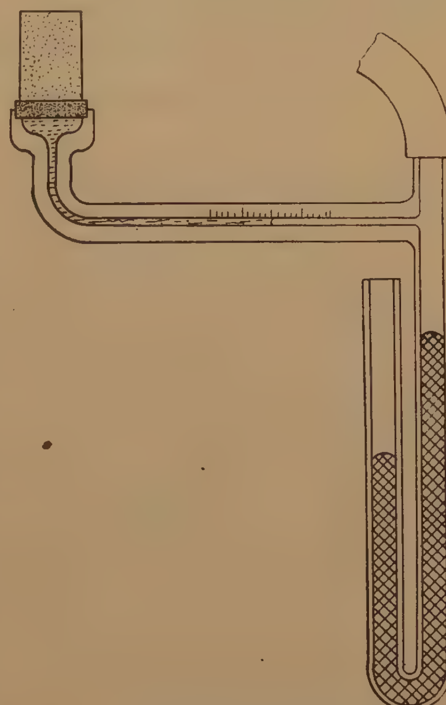

Fig. 1.—Simple device for determining relation between capillary pressure and water saturation of a rock specimen.

where the capillary pressure is zero, is known, the capillary pressure at any point in the column at which the saturation is measured is calculable. Measurements of this type have been repeated with good results and the method can be adapted to measuring either branch of the hysteresis loop.[2] This method of measuring capillary pressure cannot be applied to oil-field rocks, however, because a rather large sample is required; indeed, if capillary pressures at moderately low saturations are to be obtained for consolidated sands, very long columns would be required and a single measurement would be a major undertaking.

Centrifuge

Theory

The difficulties with the method of gravity drainage for measuring capillary pressure arise from the small value of the acceleration of gravity at the earth's surface. If it were possible to make the measurements in a stronger gravitational field, such as exists, for example, at the surface of the planet Jupiter, a shorter column could be used. While we cannot transport our laboratories to other planets, it is possible easily to obtain accelerations several thousand times gravity by means of the centrifuge. These accelerations are not easily available for measurements strictly analogous to the gravity drainage experiments, for the liquid would redistribute itself within the core when the centrifuge is stopped prior to sectioning of the core to determine the saturation

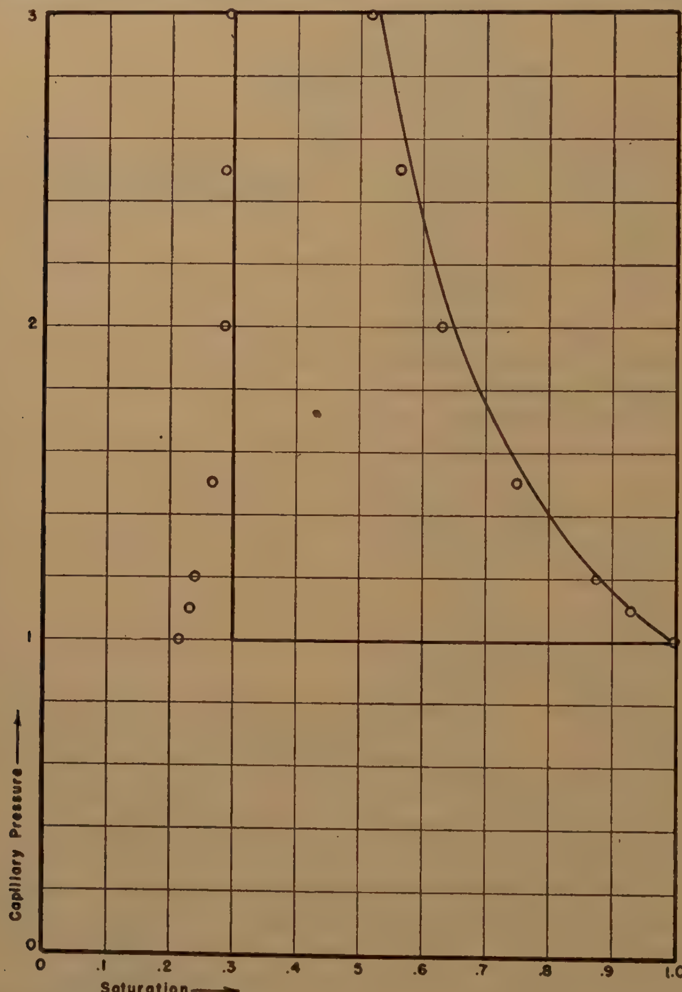

FIG. 2.—ERROR INVOLVED IN USING ONLY THE FIRST APPROXIMATION WHEN COMPUTING CAPILLARY PRESSURES FROM CENTRIFUGE DATA.

distribution, and incorrect results would be obtained. However, the use of a centrifuge introduces a new possibility: that of varying the acceleration to which the core is subjected. The average saturation of the core can be determined at the different accelerations to which it is subjected by collecting and measuring the liquid that leaves the core; and from the data obtained in this way it is indeed possible to determine the relation between capillary pressure and saturation for the core.

It should be noticed that in this procedure the centrifugal force is applied directly to the liquid in the rock; others in the field of soil physics and in petroleum engineering[3] have used centrifuges to create capillary forces in media adjacent to the specimen and have used capillary conduction to apply the suction to the specimen.

For the present discussion we may regard the capillary pressure as the independent variable that determines the saturation so that the relation between capillary pressure and saturation for a given core is expressed by a function $S(p)$, which gives the saturation s in the core at equilibrium when the capillary pressure is p. If a cylindrical core of length L containing a liquid of density ρ is subjected to an acceleration g, and if the capillary pressure at the lower face of the core is zero, then at a distance h above the lower face the capillary pressure will be ρgh and the saturation $S(\rho gh)$ so that the average saturation of the core $\bar{s}$ will be given by:

$$\bar{s} = \frac{1}{L}\int_0^L S(\rho gh)dh \qquad [1]$$

The acceleration g to which the core is subjected may be specified by the quantity

$$z = \rho gL \qquad [2]$$

which is proportional to it and which represents the total pressure developed across the core. Introducing $x = \rho gh$ as a new variable of integration into Eq. 1, and making use of Eq. 2, we find:

$$z\bar{s} = \int_0^z S(x)dx, \qquad [3]$$

from which follows

$$S(z) = \frac{d}{dz}(z\bar{s}) \qquad [4]$$

Then the capillary pressure curve $s = S(p)$ for a core can be obtained by centrifuging the core at a number of different speeds corresponding to different values of z, measuring the average saturation $\bar{s}$ for each different value of z, plotting a curve of $\bar{s}z$ against z, and measuring slopes of tangents to this curve.

In the derivation of Eqs. 3 and 4 it was assumed that the core was subjected to the same acceleration throughout its length. This is not strictly true when a centrifuge is used. If the variation of the centrifugal field with the distance from the axis of rotation is taken into account, the following relations hold instead of Eq. 3:

$$z\bar{s} = \cos^2\frac{1}{2}\theta \int_0^z \frac{S(x)dx}{\sqrt{1 - \frac{x}{z}\sin^2\theta}} \qquad [5]$$

with

$$z = \tfrac{1}{2}\rho\omega^2(r_2^2 - r_1^2) \qquad [6]$$

and

$$\cos\theta = \frac{r_1}{r_2} \qquad [7]$$

where r_1 and r_2 are the distances of the two ends of the core from the axis of rotation and ω is the angular velocity of the centrifuge.

Eq. 5 cannot be solved so simply for the unknown function S as was Eq. 3; but Eq. 3 is a good approximation to Eq. 5 for small values of θ, and its solution, given by Eq. 4, can be taken as a first approximation in a process of successive approximations to the solution of Eq. 5. By adding and subtracting $\int_0^z S(x)dx$ to

the right side and properly grouping and transposing terms, Eq. 5 may be written:

$$\int_0^z S(x)dx = z\bar{S} + \int_0^z \left[1 - \frac{\cos^2 \frac{1}{2}\theta}{\sqrt{1 - \frac{x}{z} \sin^2 \theta}} \right] S(x)dx \quad [8]$$

The second term on the right is small compared with the other terms and may be treated as a small correction term.

To solve Eq. 8 by successive approximations, first replace the correction term by zero and obtain Eq. 4 as a first approximation. The first approximation to S may then be put into the correction term, which then makes the right side of Eq. 8 a known function of z and a second approximation may be obtained by differentiation. This process may be continued until the required degree of approximation is attained. If

$$S = S_1 + S_2 + S_3 + \cdot \cdot \quad [9]$$

is put in Eq. 8 with

$$S_1(z) = \frac{d}{dz}(z\bar{S}) \quad [10]$$

the successive terms become:

$$S_{k+1}(z) = \frac{d}{dz} \int_0^z \left[1 - \frac{\cos^2 \frac{1}{2}\theta}{\sqrt{1 - \frac{x}{z} \sin^2 \theta}} \right] S_k(x)dx \quad [11]$$

Eq. 11 may be put into a form more convenient for computation by changing the variable of integration from x to x/z and differentiating under the integral sign. In this way there results:

$$S_{k+1}(z) = \int_0^1 \left[1 - \frac{\cos^2 \frac{1}{2}\theta}{\sqrt{1 - x \sin^2 \theta}} \right] G_k(xz)dx \quad [12]$$

with

$$G_k(x) = \frac{d}{dx}[xS_k(x)] \quad [13]$$

The computation of the higher approximations from Eqs. 12 and 13 is very tedious, but experience has shown that even with values of r_1/r_2 as small as 0.7 the first approximation given by Eq. 1 is usually sufficient. In order to illustrate the degree of approximation to be expected from Eq. 10, the first approximation has been calculated for two rather extreme forms of capillary-pressure curve and the results are shown in Fig. 2. The curves are hypothetical capillary-pressure curves and the points are the corresponding values of S_1 calculated from Eqs. 5 and 10, using 0.8 for r_1/r_2.

Apparatus

Attempts to measure capillary pressures of small rock samples with a rather crude apparatus adapted from an ordinary laboratory centrifuge met with considerable success; therefore the apparatus shown in Fig. 3 was constructed specifically for that purpose. It is necessary that a centrifuge for measurement of capillary pressure shall run smoothly even when considerably out of balance. This requirement was met in the present apparatus by the use of a centerless rotor, i.e., one suspended on a shaft flexible enough to bend while the rotor takes whatever center the constantly shifting liquid masses require. The damping forces required to avoid the damaging resonance vibration to which this type of construction normally gives rise[9] are supplied by a rubber damping bearing below the rotor, consisting of a leather bearing enclosed in a metal cup A surrounded by a ring of sponge rubber B which is held in a steel ring C. This bearing does not support any of the weight of the rotor, which is suspended from a ball bearing D. The suspension represents a compromise between flexibility and

strength; it consists of a rigid shaft *E* provided with two universal joints, of which one is shown at *F* and the other is hidden by the streamlined rotor cover *G*. The rotor is driven at speeds up to 4000 r.p.m. by a 1/8-hp. variable-speed a.c. motor *H*. The motor is provided with an adjustable centrifugal governor whose adjusting handle appears at *I*. This governor originally affected the speed of the motor by switching a resistance in or out of the circuit as the occasion required. When used in this way, the heavy current broken by the contacts soon causes them to become dirty and unreliable; the governor now is used with an electronic relay, with much better results. The core is held in a metal container *J*, which is provided with a graduated glass pipette *K* to collect the liquid pulled from the core. Provision is made for four core holders on the rotor, and the pipettes are read by means of a stroboscope lamp *L* operated by a contact device *M* on the motor shaft. The contact device *M* is provided with four contacts, and a selector switch enables any one of the four pipettes to be viewed as desired through the window *N*. The speed of the centrifuge is measured by measuring the voltage of a small a.c. generator *P* on the motor shaft. This tachometer was calibrated by means of a stroboscope disk on the rotor.

Technique

To measure capillary pressures with this apparatus, the extracted cores are saturated and placed in their core holders after their dry and saturated weights have been obtained. The centrifuge is then started and run at successively greater speeds, the speed being held constant at each chosen value until the cores have all attained equilibrium, as indicated by no further increase with time of the quantity of liquid contained in the pipettes. When equilibrium is attained, which takes from a few minutes to one half hour or more, the quantity of liquid in each of the pipettes is read with the aid of the stroboscope, and the speed of the centrifuge is increased.

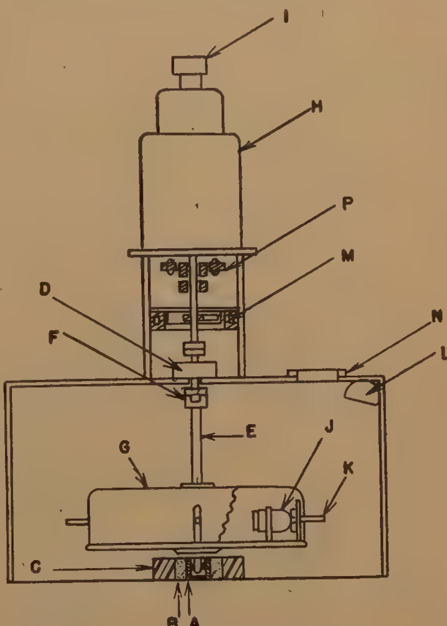

FIG. 3.—CENTRIFUGE FOR MEASUREMENT OF CAPILLARY PRESSURE.

When the run is over the cores are removed from the centrifuge and weighed to give a check on the saturation determined from the last pipette reading. The values of z for each centrifuge speed are then computed from Eq. 6, and the average saturation $\bar{s}$ of each core is obtained from the dry and saturated weights and the corresponding pipette reading. From these data a smooth curve is prepared for each core, showing $z\bar{s}$ as a function of z. The value of the saturation that goes with each value of z; which now represents the capillary pressure, is obtained from this curve by graphical differentiation in accordance with Eq. 4. If necessary, a better approximation can be obtained by a tedious combination of graphical differentiations and integrations according to

Eqs. 9, 12 and 13, but this is seldom if ever required.

If the centrifuge stops for any reason during a run, the run is spoiled, for if the centrifuge is started again and brought to its previous maximum speed more liquid is expelled from the core than before the interruption. This occurs because the liquid moves so as to redistribute itself more nearly uniformly throughout the core when the centrifugal force is no longer present to balance the capillary-pressure gradient, and the air that is drawn into the region of the core near the outlet face is not completely expelled when the centrifuge is run again. The assumptions that the saturation must be 100 per cent and the capillary pressure zero at the outflow face, under which the relation between capillary pressure and centrifuge data was derived, no longer hold and there is no way to interpret the

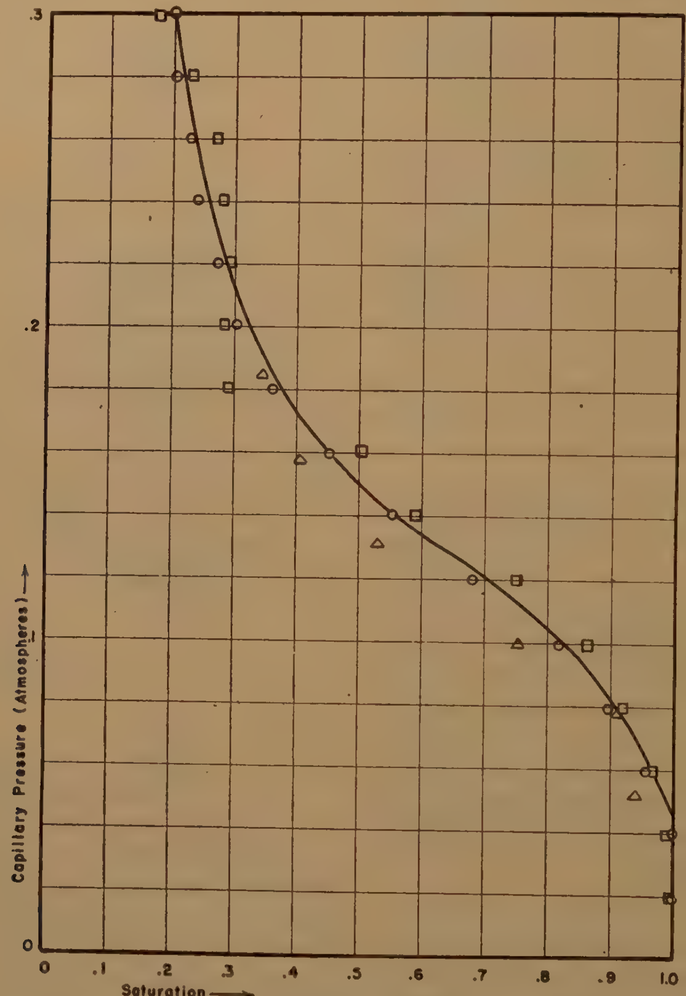

FIG. 4.—CAPILLARY PRESSURE OBTAINED WITH CENTRIFUGE (SQUARES AND CIRCLES) AND WITH CAPILLARY DIAPHRAGM (TRIANGLES).

data. For this reason it is well never to allow the speed of the centrifuge to decrease during a run, although some latitude in this regard seems to be permissible.

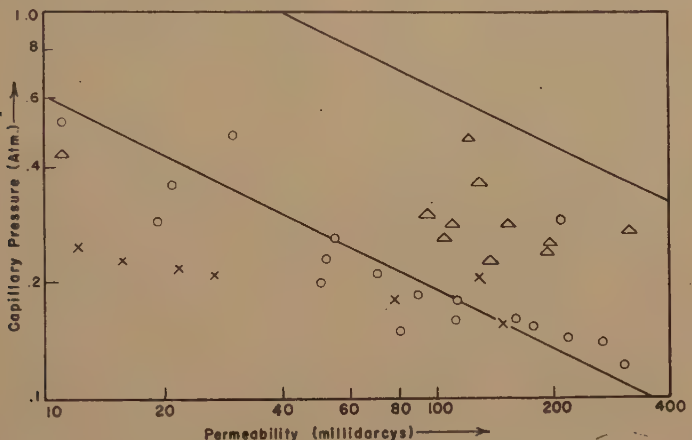

FIG. 5.—CAPILLARY PRESSURE AT 70 PER CENT WATER-SATURATION VERSUS PERMEABILITY.
○ Well-consolidated Mid-Continent sandstones.
△ Loosely consolidated California sandstones.
× Dolomitic limestones.

Results

Fig. 4 shows the capillary-pressure curve for a very permeable (300 millidarcys) sandstone core obtained with the centrifuge. The core was saturated with water and run in air. The points shown differently as circles and squares were obtained by using two different procedures in reducing the data, in order to minimize the personal factor that necessarily enters the computation when the centrifuge data are smoothed prior to differentiating. The circles were obtained by plotting $\bar{s}z$ against z, drawing a smooth curve among the points, reading values of $\bar{s}z$ from this curve at evenly spaced values of z, and computing the required derivative with an interpolation formula. To obtain the squares, the data were plotted as $\bar{s}$ versus z; values of $\bar{s}$ were read at evenly spaced values of z from a smooth curve among these points and a table of $\bar{s}z$ was constructed from which the required derivative was interpolated. The points shown as triangles represent measurements on the same core made with a capillary diaphragm. The good agreement between the centrifuge data and the capillary-diaphragm measurements indicates that the assumptions made in deriving Eq. 4 are justified.

Other data obtained with the centrifuge have been published elsewhere (ref. 1, Figs. 1–3), and they show the great variation that exists in the capillary-pressure curves of different cores. If the capillary pressure in a core were a function only or primarily of the permeability of the core in addition to the properties of the fluids involved and the saturation, it should be expected, for dimensional reasons, to be inversely proportional to the square root of the permeability. Of course this relation could be expected to hold only if all porous rocks were geometrically similar, which decidedly they are not. Nevertheless the permeability of the core makes itself felt to some extent in the expected manner, as is indicated by Fig. 5, in which the capillary pressures in a number of cores at 70 per cent water saturation are plotted against their permeabilities. The lines in

the figure have a slope corresponding to the expected relation and the upper one is located so as to correspond with Leverett's measurements on unconsolidated sand.[2] The triangles represent loosely consolidated California sandstones; the circles, well-consolidated Mid-Continent sandstones; the crosses, dolomitic limestones from Texas. The Mid-Continent sandstones follow the anticipated relation quite closely. The loosely consolidated sands behave more like unconsolidated sands at the saturation involved, although many of these same cores showed a wide divergence from unconsolidated sand in their behavior at lower saturations. The dolomitic limestones show a much weaker dependence of capillary pressure on permeability than inverse proportionality to the square root, which shows definitely that the low-permeability cores of this type are not geometrically similar to those of high permeability. A dependence of capillary pressure on porosity in addition to its dependence on permeability has not been found.

Cavitation

Many of the capillary-pressure curves previously published that were obtained with the centrifuge were extended to capillary pressures well above one atmosphere,[1] and measurements have been obtained at capillary pressures above three atmospheres. Since the air in the core was always at atmospheric pressure, the liquid in the upper part of the core must have been at a negative pressure; i.e., under tension. Cavitation therefore suggests itself as a possible source of trouble, since this phenomenon is known to occur in Venturi tubes and other places where the pressure in a liquid would otherwise have to fall below the vapor pressure in order to verify Bernoulli's theorem.

The phenomena of cavitation are not completely understood, and it is well known that under suitable conditions liquids will support considerable tension. The conditions prevailing in a core during the measurement of capillary pressure with the centrifuge seem to be suitable conditions, for cavitation does not appear to occur. That substantially all the liquid that leaves the core during centrifuging, whether as vapor or otherwise, finds its way into the pipette and is measured is shown by the fact that the saturation of the core as determined by weight after a run agrees with that obtained from the pipette reading. If cavitation should occur, therefore, the capillary-pressure curve of a core as measured with the centrifuge would show zero saturation at capillary pressures above atmospheric, and no tendency of this kind is observed.

In a recent discussion on the formation of bubbles,[10] it was argued that the presence of nuclei of occluded gas on solid surfaces or of turbulence is necessary for the formation of bubbles in a liquid. It is not unreasonable to suppose that the process of extracting and saturating the core removes any nuclei of occluded gas that might be present, and the vibration of the centrifuge would not seem sufficient to produce turbulence in the small pores of the core; the absence of cavitation in the capillary pressure measurements is therefore understandable.

Conclusion

The centrifuge method of measuring capillary pressures suffers from some disadvantages, of which perhaps the greatest are its limitation to a single branch of the hysteresis loop and the fact that the data must be smoothed before the capillary pressures are calculated, so that an estimate of the precision of a measurement is difficult. On the other hand, this method allows the capillary-pressure curves of small consolidated core samples to be determined quickly and conveniently and to be extended to rather large values of capillary pressure. It is

believed that for some purposes this may outweigh the disadvantages. Moreover, the method is not limited to use with a liquid and a gas as the fluids in the core. By filling the core holder and pipette initially with oil, for example, and saturating the core with water, the capillary behavior of the core to oil and water may be measured directly.

ACKNOWLEDGMENTS

The encouragement of Dr. A. G. Loomis, Associate Director of the Shell Development Company's laboratories, is acknowledged, as well as the able assistance and collaboration of a number of the staff of the Shell Development Co., among whom Messrs. F. G. Bollo, T J. Deahl, E. S. Mardock and S. R. Pedersen may be specifically mentioned.

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An Analysis of Material-balance Calculations

By Rex W. Woods* and Morris Muskat,† Member A.I.M.E.

(Houston Meeting, May 1944)

Abstract

A least-square analysis procedure has been developed and applied for the study of the deviations in estimations of oil in place as given by the material-balance equations. The data used were those obtained from field observations on the Jones sand in the Schuler pool, Arkansas, and the Monroe dolomite in the Reed City pool, Michigan. Possible effects of water intrusion were taken into account by expressing the cumulative water influx in terms of various functions previously proposed in the literature. Formulas were developed and values calculated for the minimum deviations and minimal percentage deviations in the calculated volumes of oil in place from the average values, as could be obtained by suitable choice of the water encroachment and initial gas-cap volume parameters.

The results show that the fluctuations in these calculated volumes are very insensitive to the values chosen for the rate of water intrusion and initial gas-cap volume, and hence cannot be safely used in discriminating between spurious values for these parameters and such as actually pertain to the producing reservoirs. Moreover, the exact form of the water-intrusion function seems to have but little effect on the fluctuations in the computed oil in place.

Accordingly, it is concluded that the material-balance method does not of itself provide a satisfactory criterion for determining the basic physical unknowns of producing reservoirs or in making conclusive decisions regarding the production mechanism, unless independently established geological control data are available for eliminating unreasonable values for the reservoir parameters, even though they may still satisfy the material-balance formulas. If, however, from core or logging data the initial oil in place and the gas-cap volume can be established in advance, the material-balance formulas can be inverted to find the water intrusion. Moreover, by determining by such calculations the water-intrusion coefficient, the future production performance can then be predicted by the aid of the material-balance formulas for specified operating conditions. This type of application may be of particular value in predicting the results of pressure-maintenance operations.

Introduction

The evaluation of the forces acting upon an oil reservoir is a problem of considerable interest to the operator as an aid in determining the proper method of operation for the reservoir to obtain an optimum recovery of oil. In many pools, the nature and magnitude of the forces acting upon the reservoir remain unknown until an appreciable amount of ultimate recovery is obtained. To be of value to the operator, a reliable interpretation of reservoir performance should be available in the early life of the pool to permit an optimum plan of operation. Progress has been made in an understanding of reservoir behavior and the importance of the different factors involved. The material-balance method of estimating oil in place has been proposed as a tool in analyzing reservoir-performance problems.[1] The solution of such problems by this method ordinarily involves two or more unknown values relating to the nature of the reservoir, and the results

Manuscript received at the office of the Institute May 24, 1944. Issued as T.P. 1780 in Petroleum Technology, January 1945.

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† Gulf Research and Development Co., Pittsburgh, Pennsylvania.

[1] References are at end of paper.

must be carefully analyzed to determine the reliability that can be placed upon them in the light of these unknown factors.

It is not the purpose of this paper to present anew the material-balance method, except with respect to an analysis of the results that may be obtained by its use. Where several unknown values are involved for a series of observations, and errors in measurement unavoidably exist, a solution for the unknown values by simple methods may yield erroneous or inconsistent results, and it is necessary to obtain a fit of data that will satisfy all values with a minimum deviation. An accepted method of fitting such data when the errors are of a random type is that of least squares. Equations for application of the least-squares method to material-balance calculations have been developed and are applied to data for the Monroe reservoir of the Reed City pool, Michigan, and the Jones sand reservoir of the Schuler pool, Arkansas.

The Material-balance Equation

The theory and derivation of equations used and the data necessary for the application of material-balance calculations have been discussed in the literature.[2-6] The fundamental equations derived by different investigators are essentially the same, and differences exist mainly in the nomenclature used. Data required in the method include equilibrium data on reservoir oil and gas, gas and oil production, and pressure data. Its application is limited ordinarily to reservoirs in which the oil is saturated with gas.

The unknowns involved in the solution of the problems usually are the original volume of oil, original volume of free gas, and the rate of water entry into the reservoir during the production period. If one unknown can be eliminated, the problem is simplified, and if two of the unknown values can be assumed the third can be calculated readily. Since the original oil and gas volumes inherently are constants, one could in principle assume the values of these constants and obtain the corresponding rates of water entry by a simple calculation. Generally, however, in the application of the method the original volumes of oil and gas have been considered as unknown, to be determined simultaneously with the amount of water entry.

The general equation underlying the material-balance method may be written as:

$$Q_0 = \frac{Q_s(u + (r_p - r_0)v) - Q_{gi}(v - v_0) + z - Z}{(u - u_0)} \qquad [1]$$

where Q_0 is the original oil in place expressed as stock-tank barrels; Q_s is the cumulative oil production; Q_{gi} the initial free gas content, in cubic feet at standard conditions; z the cumulative water production; Z the cumulative water intrusion in barrels; r_p the cumulative produced gas-oil ratio (cu. ft. per bbl.); r_0 the original dissolved gas-oil ratio; v the formation volume, in barrels, of 1 cu. ft. of gas at standard conditions; v_0 the initial value of v, u the formation volume of the oil plus that of the gas originally dissolved in it,* and u_0 the initial value of u.

Q_0, Q_{gi}, and Z are unknown quantities unless it is possible to evaluate Q_0 and Q_{gi} from core or logging data. All other data are obtained from bottom-hole or separator sample analyses, production records, and pressure surveys.

Methods of Expressing Water Influx

The immediate implication of Eq. 1 is a relationship between the water influx Z as a function of time and assumed values of Q_0. This relationship is illustrated by the series of curves shown in Fig. 1, in which are plotted the variation of water influx with time, calculated by Eq. 1 for various assumed values of Q_0, expressed in units

* In terms of the formation volume of the oil itself, β, and the gas solubility, r, u may be expressed as: $u = \beta + v(r_0 - r)$.

of a fixed value $\bar{Q}$. The higher the assumed value of original oil in place, Q_0, the lower will be the water intrusion required by Eq. 1 for matching the observed pressure behavior, and conversely. In fact, the

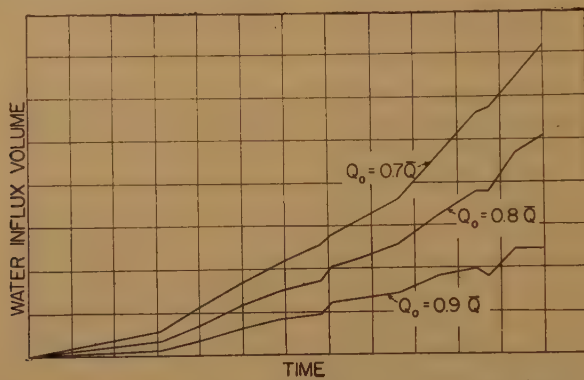

FIG. 1.—WATER INFLUX WITH TIME FOR VARIOUS VALUES OF Q_0 IN MATERIAL-BALANCE CALCULATIONS.

curves of Fig. 1 were computed merely by inverting Eq. 1 and solving explicitly for Z, so that the pressure and production data were accurately fitted with each assumed value of Q_0 by the corresponding values of water influx plotted in Fig. 1.

Thus there arises the real problem of discriminating between the curves so as to give the most reliable value of Q_0. One method thus far used[1] is to assume a relationship between Z and the pressure and time and determine the value of the constant in the relationship that gives best agreement with Eq. 1. In actual application, the degree of constancy of the values of Q_0 calculated by Eq. 1 is noted for various constant coefficients c in the equation:

$$Z = cf(p, t) \qquad [2]$$

Forms thus far proposed for the estimation of water encroachment by Eq. 1—i.e., of the function (p, t)—are:*

1. Hurst formula[7] (for radial water influx).

2. Simplified form of Hurst's formula: $c \int_0^t \frac{\Delta p}{\log t}\, dt$.

3. Schilthuis formula:[2] $c \int_0^t \Delta p\, dt$.

4. Simple approximation: $ct\Delta p$, which is equivalent to No. 3 when $\Delta p \propto t$.

The method and formulas for evaluating the water encroachment proposed by Hurst[7] take into account the transient conditions existing in the reservoir, and the simplified form of Hurst's method represents a rough evaluation of the transient conditions. It has been demonstrated that the transient effects due to the expansive power of water play an important role in the influx of water to an oil reservoir.[8–10] Sufficient knowledge of all the variables involved in the mechanism of water encroachment, however, is seldom available to permit an independent calculation of the amounts of water encroachment in the early life of the reservoir. In view of the many assumptions and approximations underlying all of the formulas, no clear-cut choice is provided for any satisfactory representation of the water encroachment function in the material-balance equation. Moreover, as will be seen in the following, with all of the

* It is to be noted that when using Hurst's formula c has the dimensions of (time × volume)/pressure, whereas in all the other functional forms the dimensions of c are those of (volume)/(pressure × time).

methods used, the fluctuations in Q_0 may vary so slowly with the parameter c that a minimum of the fluctuation may have little physical significance.

The fluctuation in Q_0 for different values of c in the expression for the water influx term will be illustrated by actual data taken in the Monroe reservoir of the Reed City pool, Michigan, and the Jones sand reservoir of the Schuler pool, Arkansas. For this purpose, the suitable formulas for calculating the fluctuation in Q_0 will be developed. Specifically, the method of least squares will be used to compute the mean-square deviations in Q_0 for all conditions that might exist.

Derivation of Formulas

Using Eq. 1, the apparent volume of oil in place may be first calculated by neglecting the volume of the gas cap and the amount of water encroachment as:

$$Q_a = \frac{Q_s(u + (r_p - r_0)v) + z}{(u - u_0)} \qquad [3]$$

This involves only direct observational data determined in the field or laboratory.

In attempting next to evaluate the water-intrusion term Z, it is generally found that the calculation of the function $f(p, t)$ is quite uncertain in the early producing period of the field, because of lack of knowledge of the pressure distribution throughout the entire water reservoir. A plausible way of correcting for this uncertainty is to assume that for the initial period used in the material-balance calculations the water-encroachment function should include a constant term. This, of course, cannot be strictly correct from a physical point of view, yet it does provide at least an approximate representation of the transient water influx during the early production history. Moreover, inverse calculations of the water influx where the values of oil in place may be assumed as known frequently show initial rapid rises such as could be approximated by a constant term. Water entering the reservoir will be expressed therefore in the general form

$$Z = cf(p, t) + a \qquad [4]$$

with the value of a to be determined by least-square considerations just as the constant c.

To derive now expressions for the fluctuations in Q_0, it is convenient to designate the remainder of the terms in Eq. 1 as follows:

$$\frac{v - v_0}{u - u_0} = \lambda; \; \frac{f(p, t)}{u - u_0} = \gamma; \; \frac{1}{u - u_0} = \alpha \qquad [5]$$

In applying Eq. 1 to specific time periods in the production, the values of Q_0 and Q_a calculated at the jth time interval will be denoted by Q_{0j}, and Q_{aj}, and the corresponding values of λ, γ, and α by λ_j, γ_j and α_j. In this notation, Eq. 1, when applied to the jth time interval, may be written as:

$$Q_{0j} = Q_{aj} - Q_{gi}\lambda_j - c\gamma_j - a\alpha_j \qquad [6]$$

For a series of time intervals the average value of Q_0 therefore will be:

$$\bar{Q}_0 = \bar{Q}_a - Q_{gi}\bar{\lambda} - c\bar{\gamma} - a\bar{\alpha} \qquad [7]$$

where $\bar{Q}_a$, $\bar{\lambda}$, $\bar{\gamma}$, and $\bar{\alpha}$ are the arithmetic averages of Q_{aj}, λ_j, γ_j, and α_j, respectively.

Expressing the residuals from the means by the notation:

$$Q_{0j} - \bar{Q}_0 = \Delta_j; \quad Q_{aj} - \bar{Q}_a = \Delta_{aj}; \quad \bar{\lambda} - \lambda_j = B_j; \quad \bar{\gamma} - \gamma_j = C_j; \quad \bar{\alpha} - \alpha_j = A_j \qquad [8]$$

the deviations in the calculated oil in place will be given by:

$$\Delta_j = \Delta_{aj} + Q_{gi}B_j + cC_j + aA_j \qquad [9]$$

The mean-square deviation, therefore, is

$$\frac{\Sigma\Delta_j^2}{n} = \frac{1}{n}\Sigma(\Delta_{aj} + Q_{gi}B_j + cC_j + aA_j)^2 \qquad [10]$$

where n is the number of time intervals used in the calculations. For a minimum

mean-square deviation, the constants Q_{gi}, c, and a must be chosen to satisfy the relations:

$$\frac{\partial\Sigma\Delta_j^2}{\partial Q_g} = \frac{\partial\Sigma\Delta_j^2}{\partial c} = \frac{\partial\Sigma\Delta_j^2}{\partial a} = 0 \quad [11]$$

Or, the choice of the parameters Q_{gi}, c and a may be based on the criterion that the percentage of root mean-square deviation is a minimum. The latter is given by:

$$E = \frac{\sqrt{\frac{\Sigma\Delta_j^2}{n}}}{\bar{Q}_0} = \frac{\sqrt{\Sigma(\Delta_{aj} + Q_{gi}B_j + cC_j + aA_j)^2/n}}{(\bar{Q}_a - Q_{gi}\bar{\lambda} - c\bar{\gamma} - a\bar{\alpha})} \quad [12]$$

and its minimal value will be achieved when Q_{gi}, c and a satisfy the relations:

$$\frac{\partial E}{\partial Q_{gi}} = \frac{\partial E}{\partial c} = \frac{\partial E}{\partial a} = 0 \quad [13]$$

Before presenting the explicit equations determining the values of Q_{gi}, c and a satisfying Eqs. 11 and 13, it is instructive to investigate somewhat the implications of the structure of Eq. 10 for the mean-square deviation. By its definition, it is a quadratic function of Q_{gi}, c and a, and hence will give a parabolic variation with these parameters. To get an idea of rate of variation with respect to c, which controls the water-intrusion term, and hence is of most practical interest, we may set $Q_{gi} = a = 0$. Expanding Eq. 10, and evaluating the summations under these conditions, it is readily found that:

$$\overline{\Delta_j^2} = \overline{\Delta_{aj}^2} + 2c(\bar{\gamma}\,\overline{Q_a} - \overline{\gamma Q_a}) + c^2(\overline{\gamma^2} - \bar{\gamma}^2) \quad [14]$$

where again the bars indicate mean values. It is thus seen that the coefficients of the parabolic term are merely the differences between two types of averages of similar terms, and hence will be relatively small. While the coefficient of c^2 is positive, and ultimately will lead to a large increase in mean-square deviation as c is increased, within the range of practical significance of the latter the mean-square deviation will vary but slowly. In other words, the mean-square deviation will be basically insensitive to the variations in the magnitude of c, and great caution should be used in applying it as a criterion for determining the true value of c, and ultimately the magnitude of the volume of oil in place.

Another point to be noted about Eq. 14 is that the existence of a true minimum in mean-square deviation, for positive values of c, will be obtained only if the quantity $\bar{\gamma}\,\overline{Q_a} - \overline{\gamma Q_a}$ is negative. If the latter is positive, the deviation will vary monotonically when c is positive; that is, the analytical minimum may require that c be negative and, similarly, that Q_{gi} be negative in the more general case.* Under such conditions the insistence on an absolute minimum deviation would, of course, lead to a physical absurdity. In any case, it is clear that the deviation analysis of the material-balance method can show only the character of the variation of the deviations with the magnitudes of the parameters c, Q_{gi}, and a. It cannot of itself evaluate the reliability of parameters giving one value of the deviation as compared with another set giving a different deviation magnitude. Numerical illustrations of these points will be given in the following discussion.

Although the percentage mean-square deviation is certainly of greater physical significance than the absolute value of the deviation, the formulas for its calculation are too lengthy and complex in the general case, where c, Q_{gi}, and a are all unknown, to warrant listing. Therefore they will be given only in a few simple cases to indicate their structure, as compared with those for the mean-square deviation.

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* Such a situation actually arises in connection with Schuler, where the requirement of minimum percentage deviation, with no water drive, leads to negative values of the free gas volume Q_{gi} (cf. case 3 of Table 3).

For the various situations to which the material-balance method theoretically would apply, the minimal deviation formulas are as follows:

Case 1: No gas cap or water influx:

$$\bar{Q}_0 = \bar{Q}_a; \qquad \overline{\Delta_j^2} = \overline{\Delta_{aj}^2} \qquad [15]$$

Case 2: $Q_{gi} = 0$ or known; $a = 0$.

For minimum mean-square deviation:

$$c = -\Sigma\Delta_{aj}C_j/\Sigma C_j^2 \qquad [16]$$

For minimum percentage of mean-square deviation:

$$c = -\frac{\bar{Q}_a\Sigma\Delta_{aj}C_j + \bar{\gamma}\Sigma\Delta_{aj}^2}{\bar{Q}_a\Sigma C_j^2 + \bar{\gamma}\Sigma\Delta_{aj}C_j} \qquad [17]$$

Case 3: $Q_{gi} = 0$ or known: $a, c \neq 0$.

$$Q_{gi} = -\frac{\bar{Q}_a\Sigma\Delta_{aj}B_j + \bar{\lambda}\Sigma\Delta_{aj}^2}{\bar{Q}_a\Sigma B_j^2 + \bar{\lambda}\Sigma\Delta_{aj}B_j} \qquad [20]$$

Case 5: $a = 0$; Q_{gi} and c are unknown.

Formulas are same as for case 3, with A_j replaced by B_j, $\bar{\alpha}$ replaced by $\bar{\gamma}$, and a by Q_{gi}, wherever these occur.

Case 6: Q_{gi}, a, c, are all unknowns.

For minimum least-square deviations, Q_{gi}, a, and c must satisfy the equations:

$$\left.\begin{aligned} Q_{gi}\Sigma A_jB_j + a\Sigma A_j^2 + c\Sigma A_jC_j &= -\Sigma\Delta_{aj}A_j \\ Q_{gi}\Sigma C_jB_j + a\Sigma A_jC_j + c\Sigma C_j^2 &= -\Sigma\Delta_{aj}C_j \\ Q_{gi}\Sigma B_j^2 + a\Sigma A_jB_j + c\Sigma C_jB_j &= -\Sigma\Delta_{aj}B_j \end{aligned}\right\} \qquad [21]$$

TABLE 1.—*Data for Material-balance Calculations, Monroe Reservoir, Reed City Pool*
$u_0 = 1.338$; $r_0 = 687$

Date	Average Reservoir Pressure, Lb. per Sq. In. Gauge	Q_s, Million Bbl.	z, Million Bbl.	$r_p - r_0$, Cu. Ft. per Bbl.	10^3v, Bbl. per Cu. Ft.	$u + (r_p - r_0)v$	$u - u_0$	Q_o, Million Bbl.
1941								
June.....	1,416	0	0	0	1.478	1.338	0	
1942								
Feb. 1...	1,297	3,306	0.018	0	1.634	1.387	0.0481	95.77
Mar. 1...	1,276	3,750	0.022	0	1.660	1.396	0.0583	90.08
Apr. 1...	1,260	4,274	0.027	0	1.692	1.404	0.0662	90.91
May 1...	1,232	5,012	0.039	7	1.741	1.430	0.0802	89.99
June 1...	1,199	5,831	0.052	30	1.800	1.492	0.0995	87.82
July 1...	1,168	6,665	0.067	52	1.847	1.552	0.1180	88.17
Aug. 1...	1,133	7,479	0,084	72	1.916	1.617	0.1414	86.09
Sept. 1...	1,113	8,295	0.108	94	1.962	1.679	0.1558	90.20
Oct. 1....	1,081	9.075	0.141	113	2.032	1.750	0.1816	88.28
Nov. 1...	1,049	9,879	0.186	134	2.107	1.826	0.2074	87.90
Dec. 1...	1,017	10,658	0.240	155	2.186	1.912	0.2343	88.13
1943								
Jan. 1....	984	11,460	0.306	179	2.286	2.016	0.2680	87.34

For minimum mean-square deviation, a, c must satisfy the equations:

$$\left.\begin{aligned} a\Sigma A_j^2 + c\Sigma A_jC_j &= -\Sigma\Delta_{aj}A_j \\ a\Sigma A_jC_j + c\Sigma C_j^2 &= -\Sigma\Delta_{aj}C_j \end{aligned}\right\} \qquad [18]$$

Case 4: No water influx. Q_{gi} unknown.

For minimum mean-square deviation:

$$Q_{gi} = -\frac{\Sigma\Delta_{aj}B_j}{\Sigma B_j^2} \qquad [19]$$

For minimum percentage mean-square deviation:

The explicit solutions for achieving a minimum percentage in mean-square deviation have been derived, but are too lengthy for reproduction. It should be emphasized, however, that even the solutions listed above are thus recorded only for convenience in special circumstances where their use may be justified, as in case 4. But they are not to be construed as means for computing unique and unambiguous values for the unknowns of interest. For, as will be seen below, the constants determined by these equations

Table 2.—*Sample Calculation of Least-square Terms*

Date	$10^{-6}Q_{oj}$, Bbl.	$10^{-6}\Delta_{oj}$, Bbl.	$10^{-12}\Delta_{oj}^2$, Bbl.²	α_j	A_j $(\bar{\alpha} - \alpha_j)$	A_j^2	$10^3\lambda_j$, Bbl. per Cu. Ft.	10^3B_j $(\bar{\lambda} - \lambda_j)$
1938								
July	111.000	−5.006	25.060	25.000	−20.612	424.86	2.308	−0.268
Oct.	114.993	−1.013	1.026	14.859	−10.471	109.64	2.309	−0.269
1939								
Jan.	119.425	+3.419	11.690	11.494	− 7.106	50.50	2.257	−0.217
Apr.	118.964	+2.958	8.750	9.091	− 4.703	22.12	2.355	−0.315
July	116.957	+0.951	0.904	7.210	− 2.822	7.96	2.257	−0.217
Aug.	120.705	+4.699	22.081	7.194	− 2.806	7.87	2.265	−0.225
Oct.	119.664	+3.658	13.381	6.329	− 1.941	3.77	2.222	−0.182
1940								
Jan.	117.513	+1.507	2.271	5.118	− 0.730	0.53	2.169	−0.129
Apr.	117.293	+1.287	1.656	4.040	+ 0.348	0.12	2.125	−0.085
July	114.775	−1.229	1.510	3.165	+ 1.223	1.50	2.040	0
Aug.	112.111	−3.895	15.171	2.849	+ 1.539	2.37	2.032	+0.008
Oct.	113.957	−2.049	4.198	2.503	+ 1.885	3.55	1.996	+0.044
Dec.	111.884	−4.122	16.991	2.151	+ 2.237	5.00	1.968	+0.072
1941								
Jan.	112.249	−3.757	14.115	2.041	+ 2.347	5.51	1.959	+0.081
Feb. 14	111.515	−4.491	20.169	1.988	+ 2.400	5.76	1.955	+0.085
Feb. 28	112.558	−3.448	11.889	1.984	+ 2.404	5.78	1.957	+0.083
Mar.	114.450	−1.556	2.421	1.965	+ 2.423	5.87	1.956	+0.084
Apr.	114.336	−1.670	2.789	1.896	+ 2.492	6.21	1.946	+0.094
May	115.187	−0.819	0.671	1.847	+ 2.541	6.46	1.943	+0.097
June	116.186	+0.180	0.032	1.802	+ 2.586	6.69	1.936	+0.104
July	115.766	−0.240	0.058	1.747	+ 2.641	6.97	1.931	+0.109
Aug.	115.693	−0.313	0.098	1.724	+ 2.664	7.10	1.929	+0.111
Sept.	115.858	−0.148	0.022	1.715	+ 2.673	7.14	1.926	+0.114
Oct.	117.069	+1.063	1.130	1.724	+ 2.664	7.10	1.927	+0.113
Nov.	117.697	+1.691	2.859	1.724	+ 2.664	7.10	1.927	+0.113
Dec.	116.622	+0.616	0.380	1.695	+ 2.693	7.25	1.908	+0.132
1942								
Jan.	118.311	+2.305	5.313	1.706	+ 2.682	7.19	1.925	+0.115
Feb.	118.367	+2.361	5.574	1.692	+ 2.696	7.27	1.922	+0.118
Mar.	119.229	+3.215	10.336	1.695	+ 2.693	7.25	1.923	+0.117
Apr.	119.858	+3.852	14.838	1.695	+ 2.693	7.25	1.923	+0.117
Average	116.006			4.388			2.040	
Σ			217.383			753.69		

may give deviations that are only negligibly smaller than those resulting from the use of widely different values of Q_{oi}, a or c.

Application of Formulas to Data on Jones Sand, Schuler Field, Arkansas and Monroe Dolomite, Reed City Pool, Michigan

Performance data and material-balance calculations for the Jones sand, Schuler pool, Arkansas, have been discussed in detail by Old,[1] and these data have been used as one illustration of the least-square analysis method. In addition, a considerable amount of data for the Reed City pool were obtained directly for an analysis of its reservoir performance.

The Monroe dolomite reservoir of the Reed City pool was discovered in June 1941. Monthly bottom-hole pressure and gas-oil ratio surveys were made throughout the pool beginning Feb. 1, 1942. Originally the reservoir pressure at minus 2400 ft. was 1416 lb. per sq. in., and no gas cap of significance was observed. Geological data on the extent and permeability of the productive zone indicated that water influx should be anticipated as the reservoir pressure declined.

On Jan. 1, 1943, accumulated production from the Monroe dolomite was 11,460,000 bbl., and the reservoir pressure had declined to 984 lb. per sq. in. Water production from the Monroe reservoir was approximately 2200 bbl. per day. Fifty wells of the total of 168 wells were producing water in amounts up to 550 bbl. per day. Two major operators made periodic

from Material-balance Data for Schuler Pool

$10^8 B_j^2$	γ_i $\frac{f(p, t)}{(u - u_0)'}$ Lb. per Sq. In. per Day	C_j $(\bar{\gamma} - \gamma_i)$	$10^{-6} C_j^2$	$10^8 A_j B_j$	$10^{-6} A_j C_j$	$B_j C_j$	$10^{-6} A_j \Delta_{aj}$	$10^{-3} B_j \Delta_{aj}$	$10^{-9} C_j \Delta_{aj}$
7.182	48,150	+25,783	664.76	+ 5.524	−0.5314	− 6.910	+103.184	+1.3416	−129.07
7.236	52,794	+21,139	446.86	+ 2.817	−0.2214	− 5.686	+ 10.607	+0.2725	− 21.41
4.709	64,746	+ 9,187	84.40	+ 1.542	−0.0653	− 1.994	− 24.295	−0.7419	+ 31.41
9.923	71,373	+ 2,560	6.55	+ 1.481	−0.0120	− 0.806	− 13.911	−0 9318	+ 7.57
4.709	75,128	− 1,195	1.43	+ 0.612	+0.0034	+ 0.259	− 2.684	−0.2064	− 1.14
5.063	82,400	− 8,467	71.69	+ 0.631	+0.0238	+ 1.905	− 13.185	−1.0573	− 39.79
3.312	85,176	−11,243	126.41	+ 0.353	+0.0218	+ 2.046	− 7.100	−0.6658	− 41.13
1.664	71,887	+ 2,046	4.19	+ 0.094	−0.0015	− 0.264	− 1.100	−0.1944	+ 3.08
0.723	79,879	− 5,946	35.36	− 0.030	−0.0021	+ 0.505	+ 0.448	−0.1094	− 7.65
0	67,310	+ 6,623	43.86	0	+0.0081	0	− 1.503	0	− 8.14
0.006	71,077	+ 2,856	8.16	+ 0.012	+0.0044	+ 0.023	− 5.994	−0.0312	− 11.12
0.194	69,909	+ 4,024	16.19	+ 0.083	+0.0076	+ 0.177	− 3.862	−0.0902	− 8.24
0.518	66,494	+ 7,439	55.34	+ 0.161	+0.0166	+ 0.536	− 9.221	−0.2968	− 30.66
0.656	65,761	+ 8,172	66.78	+ 0.190	+0.0192	+ 0.662	− 8.818	−0.3043	− 30.70
0.723	66,318	+ 7,615	57.99	+ 0.204	+0.0183	+ 0.647	− 10.778	−0.3817	− 34.20
0.689	67,750	+ 6,183	38.23	+ 0.200	+0.0149	+ 0.513	− 8.289	−0.2862	− 21.32
0.706	69,852	+ 4,081	16.65	+ 0.204	+0.0099	+ 0.343	− 3.770	−0.1307	− 6.35
0.884	70,317	+ 3,616	13.07	+ 0.234	+0.0090	+ 0.339	− 4.162	−0.1570	− 6.04
0.941	71,433	+ 2,500	6.25	+ 0.246	+0.0063	+ 0.243	− 2.081	−0.0794	− 2.05
1.082	72,430	+ 1,503	2.26	+ 0.269	+0.0039	+ 0.156	+ 0.465	+0.0187	+ 0.27
1.188	72,401	+ 1,532	2.35	+ 0.288	+0.0040	+ 0.167	− 0.634	−0.0262	− 0.37
1.232	75,210	− 1,277	1.63	+ 0.296	−0.0034	− 0.142	− 0.834	−0.0347	+ 0.40
1.300	77,085	− 3,152	9.93	+ 0.305	−0.0084	− 0.359	− 0.396	−0.0169	+ 0.47
1.277	77,792	− 3,859	14.89	+ 0.301	−0.0103	− 0.436	+ 2.832	+0.1201	− 4.10
1.277	83,199	− 9,266	85.86	+ 0.301	−0.0247	− 1.047	+ 4.505	+0.1911	− 15.67
1.742	83,594	− 9,661	93.33	+ 0.355	−0.0260	− 1.275	+ 1.659	+0.0813	− 5.95
1.323	87,171	−13,238	175.24	+ 0.308	−0.0355	− 1.522	+ 6.182	+0.2651	− 30.51
1.392	87,847	−13,914	193.46	+ 0.318	−0.0375	− 1.642	+ 6.365	+0.2786	− 32.85
1.369	90,710	−16,777	281.27	+ 0.315	−0.0452	− 1.963	+ 8.658	+0.3762	− 53.94
1.369	92,794	−18,861	355.74	+ 0.315	−0.0508	− 2.207	+ 10.373	+0.4507	− 72.65
64.389	73,933		2,980.13	+17.929	−0.9043	−17.732	+ 32.661	−2.3464	−571.85

bottom-hole pressure surveys at approximately 50 per cent of their wells, alternating the wells at monthly periods, and complete representative surveys were obtained. Gas-oil ratios were measured monthly at about 25 per cent of the wells in the pool. Data for the application of material-balance calculations and the results for the Monroe reservoir of the Reed City pool are shown in Table 1.

Table 2 illustrates the method of calculating the different terms involved in the least-square formulas for the data on the Schuler pool published by Old. The values of the function $f(p, t)$ were taken from Old's paper, as computed by Hurst's formula. Since the residuals often are very small, the numerical work has been carried out and recorded to much higher precision than the accuracy of the basic data would otherwise warrant.

Inspection of the data for the Schuler pool indicates that fluctuations of Q_0 probably will be small for all conditions that might reasonably be assumed to exist in the reservoir. For the purpose of analysis, the fluctuations of Q_0 have been calculated from the data for minimum deviation and minimum percentage deviation on the assumption that anyone of the six conditions listed above might obtain. Here, too, the water-influx function was that calculated by Hurst's formula and listed in Table 2.

The results of these calculations are shown in Table 3. Values of Q_0 ranging from 87.72 million barrels to 116.01 million barrels are obtained for minimum per-

centage root mean-square deviations that range only from 1.51 per cent to 2.32 per cent. For the minimum values of the absolute root mean-square deviations, Q_0 ranges from 75.34 to 116.01 million barrels, and the percentage deviations from 1.61 to 2.43 per cent.

As a further illustration of the effect of the different variables on the fluctuations of Q_0, the method of least squares was applied for different methods of estimating water influx into the Reed City Monroe reservoir, where no gas cap existed initially. A tabulation, similar to Table 2, of the corresponding least-square analysis terms shows that if a be taken as zero in representing the water influx, no water influx could have occurred ($c < 0$), since $\Sigma C_j \Delta_{aj}$ is positive (cf. Eqs. 16 and 17). To establish the general conditions for minimal deviations, the influx at the time of the first complete pressure survey has been expressed therefore as a constant a, and it has been assumed that the Hurst and Schilthuis functions represent the water influx thereafter. In regard to the Schuler pool, it has also been assumed that the water influx at the time of the first survey period used should be corrected by a constant a, because of possible failure of the different methods to properly evaluate the effect of the initial transients.

Table 4 shows a comparison of the values obtained for the Jones sand of the Schuler field and the Monroe dolomite of the Reed City pool by the different methods of estimating water influx into the reservoir, as just outlined, for the conditions of minimum percentage root mean-square deviation. The units for c are different for the second and last two rows, as indicated in the footnote on page 3.

This table shows that for the Schuler field, the Hurst formula and simplified Hurst formula give results in good agreement, while the Schilthuis formula yields a higher value for the gas cap and a correspondingly lower value for the oil in place. The deviation in Q_0 with no water drive, based on Old's data, is 2.16 per cent, compared with a minimum deviation of 1.51 per cent when water influx is assumed. For Reed City, the values obtained by the simplified form of Hurst's formula and the Schilthuis formula are in good agreement, while the Hurst formula gives higher values of Q_0 and lower values for water influx. Here the percentage deviation of Q_0 for zero water influx is 1.58, as compared with 1.06 for a water influx of appreciable amount.

The variation of water influx with time into the Jones-sand reservoir of the Schuler field and the Monroe dolomite reservoir of the Reed City pool, calculated from the different values of a and c in Table 4, are shown in Figs. 2 and 3.* For Schuler, the three different methods show a maximum difference in total water influx of 17 per cent, and it is difficult to make a choice of preference among the different values. For the Reed City pool, the water influx calculated by the simplified Hurst formula and the Schilthuis formula are in excellent agreement. The values obtained by the Hurst method are in poor agreement with the others.

As previously mentioned, material-balance calculations in the Reed City pool to Jan. 1, 1943, indicate no water influx into the reservoir when a water-influx term with $a = 0$ is used. However, the introduction of the constant a leads to a water influx of an important amount. From a study of lithological descriptions and core-analysis data on 14 cores from the Monroe dolomite, the maximum value of Q_0 was estimated as 65 million barrels. It may be coincidental that the calculated values for $a \neq 0$ are in substantial agreement with this, but it is now recognized that water influx into the reservoir is important.

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* The values of Q_0 corresponding to the different curves are, of course, different, being those given in Table 4.

This fact is illustrated by performance data for the pool shown in Fig. 4. On May 1, 1943, the reservoir pressure had declined from an initial value of 1416 lb. per sq. in. to 863 lb. per sq. in. Average recovery of oil for this period was 25,900 bbl. per pound per square inch drop in reservoir pressure. A pressure survey on Oct. 1, 1943, showed an average pressure of 779 lb. per sq. in. For the period from May 1, 1943, to October 1, 1943, 3,000,000 bbl. of oil was produced with a recovery of 36,000 bbl. per pound per square inch decline.* At this time, water production from the Monroe dolomite wells had increased to 6500 bbl. per day in spite of eliminating more than 1000 bbl. per day by plugging back operations.

TABLE 3.—*Comparison of Deviations of Q_0 for Different Reservoir Conditions, Schuler Pool, Arkansas*

MATERIAL-BALANCE DATA OF OLD[1]

Case	Minimum Mean-square Deviation						Minimum Percentage Least-square Deviation					
	c, Bbl. per Day per Lb. per Sq. In.	$10^{-6}a$, Bbl.	$10^{-6}Z$, Bbl.[a]	$10^{-6}Q_{gi}$, Cu. Ft.	$10^{-6}Q_0$, Bbl.	Root Mean-square Deviation in Q_0, Per Cent	c, Bbl. per Day per Lb. per Sq. In.	$10^{-6}a$, Bbl.	$10^{-6}Z$, Bbl.[a]	$10^{-6}Q_{gi}$, Cu. Ft.	$10^{-6}Q_0$, Bbl.	Root Mean-square Deviation in Q_0, Per Cent
1	0	0	0	0	116.01	2.32	0	0	0	0	116.01	2.32
2	191.89	0	10.5	0	101.82	1.86	165.66	0	9.1	0	103.76	1.84
3	281.08	0.2939	15.7	0	93.94	1.61	254.40	0.2542	14.2	0	96.08	1.56
4	0	0	0	3,644	108.57	2.43	0	0	0	0[b]	116.01	2.32
5	255.42	0	14.0	10,678	75.34	1.65	190.85	0	10.4	6,737	88.15	1.60
6	261.48	0.0367	14.4	9,822	76.48	1.62	246.27	0.1380	13.6	4,645	87.72	1.51

[a] To April 1942.
[b] True minimum percentage deviation requires, according to Eq. 20, a negative value of Q_{gi}. Closest physical approximation is $Q_{gi} = 0$, as in case 1.

TABLE 4.—*Comparison of Minimum Deviation Values by Different Methods of Expressing Water Influx*

Method of Expressing Water Influx	Jones Sand, Schuler Pool, Arkansas						Monroe Reservoir, Reed City Pool, Michigan				
	c	$10^{-6}a$, Bbl.	$10^{-6}Z$ (Total), Bbl.	$10^{-6}Q_{gi}$, Cu. Ft.	$10^{-6}Q_0$, Bbl.	Root Mean-square Deviation in Q_0, Per Cent	c	$10^{-6}a$, Bbl.	$10^{-6}Z$ (Total), Bbl.	$10^{-6}Q_0$, Bbl.	Root Mean-square Deviation in Q_0, Per Cent
Zero water influx	0	0	0	6,669[a]	104.42	2.16	0	0	0	88.63	1.58
Hurst method	246.3	0.1380	13.62	4,645	87.72	1.51	352.7	0.436	4.08	72.07	1.16
Simplified Hurst method	43.0	0.1299	12.57	5,162	88.54	1.60	356.0	1.329[b]	6.61	62.80	1.09
Schilthuis method	5.6	0.1090	11.30	9,343	82.55	1.74	59.3	1.348[b]	6.61	63.17	1.06

[a] From Old's assumed data.
[b] Value of water influx to Feb. 1, 1942.

DISCUSSION OF RESULTS

The numerical results given in Tables 3 and 4 and in Figs. 2 and 3 show that the

* While this evidence is not conclusive, it may be considered as confirmatory. Moreover, more recent observations on the rise in number of water-producing wells and the nature of their distribution make it now quite obvious that there is a material entry of water into the reservoir.

material-balance method possesses very little discriminating power, not only with respect to the value of the original oil in place but also with regard to the basic features of the production mechanism. Thus Table 3 shows the assumption that in the Schuler pool there is no water drive and that originally there was no gas cap* to lead to an estimated volume of initial oil in place of 116 million barrels. Moreover, the deviations in the individual

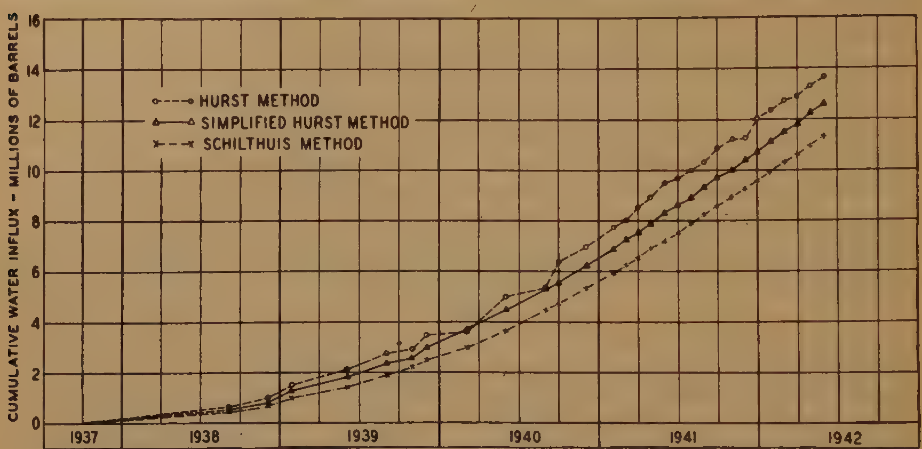

FIG. 2.—COMPARISON OF WATER INFLUX WITH TIME FOR JONES-SAND RESERVOIR, SCHULER POOL, BY METHOD OF LEAST-SQUARES SOLUTION OF MATERIAL BALANCE EQUATIONS FOR DIFFERENT METHODS OF REPRESENTING WATER INFLUX.

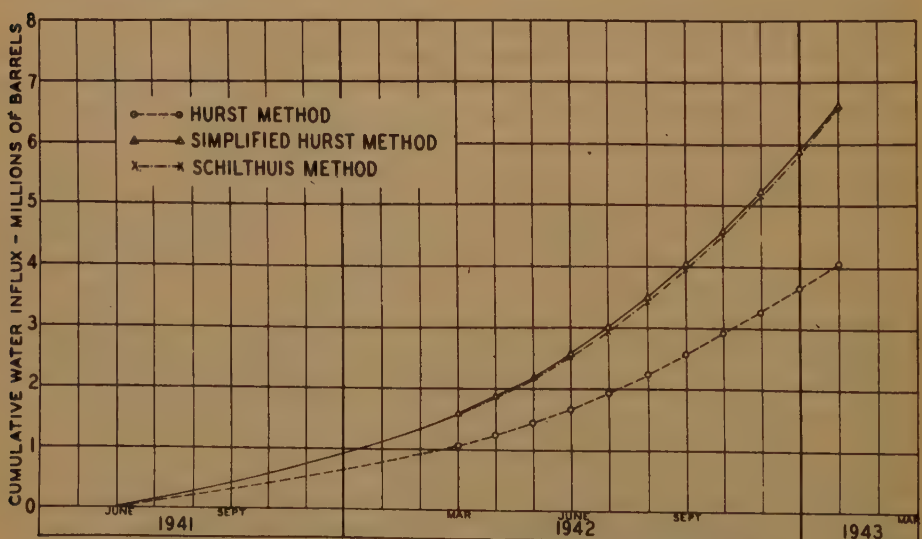

FIG. 3.—COMPARISON OF WATER INFLUX WITH TIME FOR MONROE RESERVOIR, REED CITY POOL, BY METHOD OF LEAST-SQUARES SOLUTION OF MATERIAL-BALANCE EQUATIONS FOR DIFFERENT METHODS OF REPRESENTING WATER INFLUX.

* It should be noted that while for virgin pays Q_{gi} will generally be interpreted as a gas-cap volume, it represents only a free gas volume, regardless of segregation, as far as the analysis is concerned.

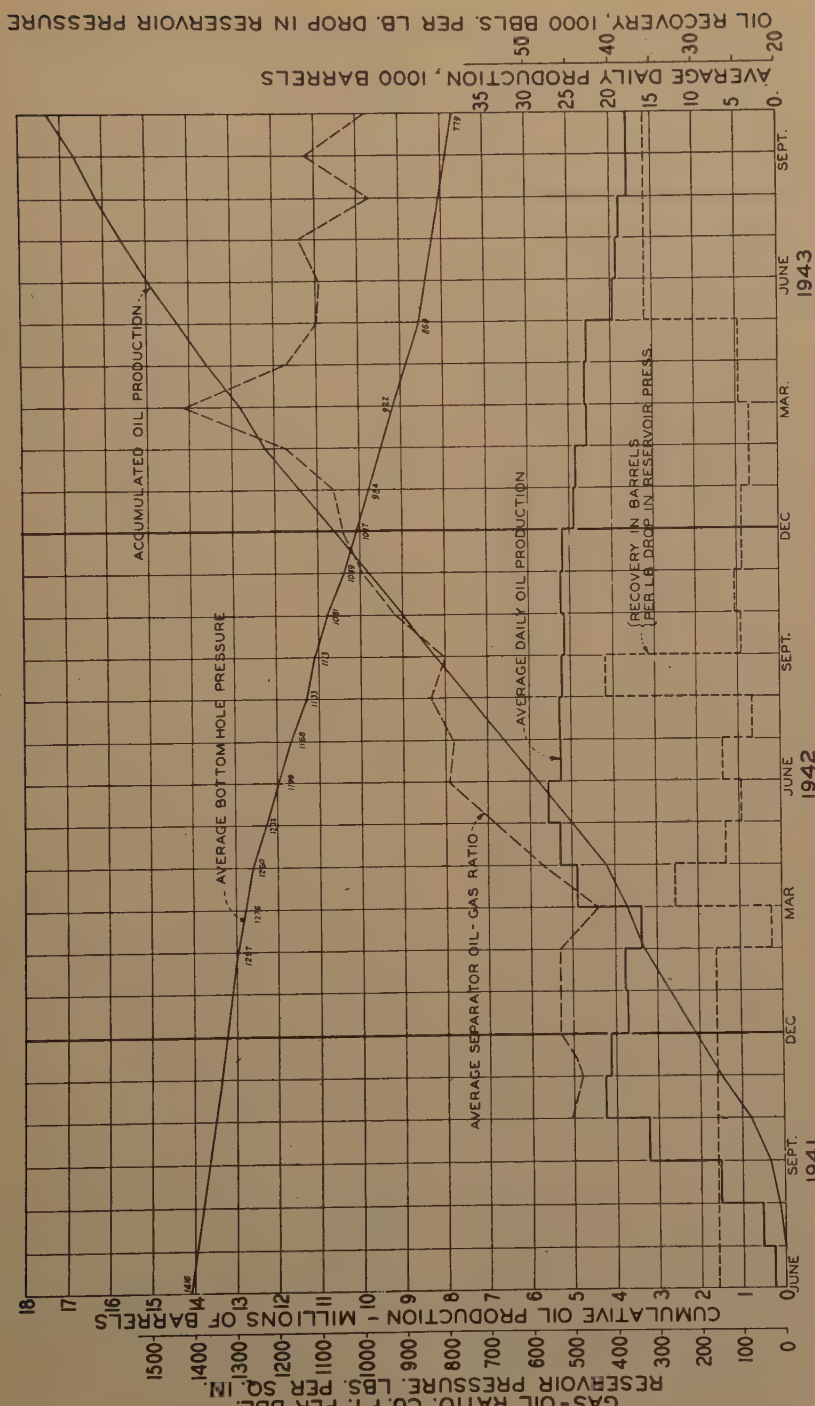

FIG. 4.—PERFORMANCE HISTORY OF MONROE RESERVOIR, REED CITY POOL.

calculated values of the oil in place from this average value over 30 observational periods is only 2.3 per cent. However, the same observational data can be fitted with a mean deviation of but 2.4 per cent if the oil in place be taken as 108.6 million barrels and the field is assumed to have originally had a gas cap containing 3.6 billion cubic feet of gas.

By dropping the assumption that initially there was present a free gas cap, but assuming that 15.7 million barrels of water had entered the reservoir, one obtains an original volume of oil in place of 93.9 million barrels with a mean deviation of 1.6 per cent. Finally, it is possible to fit the observed data to the extent that the deviation in calculated oil in place is again only 1.6 per cent, by cutting the assumed value of the oil in place to 75.3 million barrels and visualizing the reservoir as initially having 10.7 billion cubic feet of gas, and that 14.0 million barrels of water has entered the reservoir up to April 1942. Thus values of initial oil in place varying by 40 million barrels, initial free-gas volumes varying from 0 to 10.7 billion cubic feet, and amounts of water intrusion varying from 0 to 15.7 million barrels, can all be made to fit the production data with variations in the material-balance deviations ranging only from 1.6 to 2.4 per cent. Quite similar comparisons can be made for the Monroe reservoir in the Reed City pool.

When it is realized that the data for gas-oil ratio that must be used for material-balance calculations are seldom obtained with high precision, and that the reservoir pressures that enter the equations are practically always averages over individual well pressures varying over considerable ranges, it would seem that to obtain a fit of field data with any theoretical formulas with a fluctuation no greater than 2 or 3 per cent is already a remarkable achievement. To go further and discriminate between unknown parameters in the theoretical formulas on the basis that the fluctuations in the fit of the observed data may be better in one case than in another by less than one per cent would certainly imply a faith in the accuracy of the data far beyond the most optimistic expectations of the practical petroleum engineer. Moreover, when a choice between such assumptions also involves differences in original oil in place of 30 per cent and major changes in the type of production mechanism controlling the reservoir, it would appear that differences of fluctuation of the order of only one per cent must represent but a very flimsy basis for supporting such important practical conclusions.

Another important and related feature of the material-balance method, which is brought out by Table 4, is the fact that literally it provides no significant discrimination between various methods of calculating the water influx. Thus, of the three methods of calculating water intrusion listed in Table 4 the total water influx (to April 1942) for conditions providing a minimum percentage deviation vary for Schuler from 13.6 to 11.3 million barrels, the gas-cap volume from a content of 4.6 to 9.3 billion cubic feet, and initial oil in place from 88.6 to 82.6 million barrels. And the values of the deviation in the calculated volumes of oil in place vary by only 0.23 per cent. In fact, even the simple approximation: $f(p, t) = t\Delta p$ gives only 2.1 per cent deviation if Q_{gi} be taken as zero, $Q_0 = 94.02 \times 10^6$ bbl. and the total water intrusion $= 14.0 \times 10^6$ bbl. Likewise, in the Reed City pool, where zero gas-cap volume was assumed, the calculated water influx varies from 4.1 to 6.6 million barrels, and the average calculated volumes of oil in place from 72.1 to 62.8 million barrels, with a range in deviation of only 0.1 per cent. Again it is clear that on a basis of such results it is futile to attempt to make a logical choice as to the best formula to be used for calculating water influx.

The situation, unfortunately, thus reduces to the proposition that the material-balance method in itself cannot be safely used in estimating oil in place or in determining the nature of the production mechanism, except under very specialized and limited circumstances. It provides no means of significant resolving power whereby one may establish by its use the true and unambiguous values of the physical constants pertaining to the original reservoir conditions, and the type of production mechanism that is controlling its performance. In other words, the mere fact that a set of assumptions regarding the nature of the original reservoir and of the type of drive provides a fit with the observed production and pressure data with deviations or errors of the order of 1 or 2 per cent can carry but little weight as evidence that the assumptions are sound.

These conclusions, while indeed disappointing, are not surprising from a physical point of view; for it must be recognized that the material-balance equations are nothing more than expressions of the requirements of conservation of mass for the oil and gas and of the volume of the reservoir pore space, as if the reservoir were merely a sand-free tank. It is to be anticipated therefore that any observed pressure reaction of such a vessel to fluid withdrawals could be approximately duplicated on the basis of a great variety of assumptions regarding the initial size of the tank and of its fluid distribution, and especially when supplemented by an arbitrary choice of the degree of water intrusion. Records of a gradual advance of edge water or the initial penetration of a gas cap have no place in the equations, except as such observations can be crystallized into an *a priori* quantitative evaluation of the basic parameters Q_{oi} or c. Hence they can be introduced only as qualitative evidence in indicating a choice among the great variety of possible fits with the material-balance equations. However, the deviations alone are far too insensitive to provide a satisfactory criterion.

These qualitative physical considerations explaining the reason for the failure of the material-balance method to determine uniquely the basic reservoir parameters may also be expressed in somewhat more formal analytical language. It will be observed that the fundamental result of the material-balance theory (namely, Eq. 1) is, at least implicitly, merely a functional relationship between the reservoir pressure p and the cumulative recovery Q_s. It represents essentially a family of curves in the (p, Q_s) plane. The quantities u, v, r_0, and even the producing gas-oil ratio, constitute the equivalent of preassigned coefficients in the equation between p and Q_s. On the other hand, Q_0, Q_{oi} and c (or Z) represent a set of parameters with a triple infinity of possible individual values. Because of the simple functional p-Q_s relationship it is to be expected that there will be a rather wide range of the parameters Q_0, Q_{oi} and c, providing p-Q_s curves that will match closely any reasonably smooth empirical p-Q_s set of observations for a limited range of these variables. That is, if a least-square fit of the p-Q_s curves to the observed p-Q_s data were made by varying Q_0, Q_{oi} and c, it would be found that wide variations in the latter would not materially increase the deviations above those for the exact minimum deviation conditions. The single Eq. 1 is simply not a stringent enough requirement to fix simultaneously the values of each of the three virtually arbitrary parameters.

The question remains whether there is any inherent value in the use of material-balance considerations for reservoir study. To this one can still give an affirmative answer. However, such use of the method should be made only when there are independent controlling data that can serve as

criteria in choosing values of the unknowns giving approximately the same fits with the basic equation.

For example, if it is known that there is no water intrusion into the oil-producing reservoir, a and the coefficient c should be taken at the outset as strictly zero, even though the assumption of some degree of water intrusion may give deviations in the calculated oil in place that are even less than when the water-encroachment term is entirely ignored. Likewise, if it is known that there was no initial gas cap, the value of Q_{gi} should be taken as zero at the very beginning, as representing a positive physical fact, regardless of the effect of the inclusion of such a term on the deviations. Otherwise, the greater the number of unknown constants that are left in the equation, the smaller will be the final deviation that can be obtained by suitably adjusting these constants, and the analysis of the problem will end in the same type of uncertainty as exhibited for the Reed City and Schuler fields.

A more positive and useful application of the material-balance method can be made if, by means of core analysis, electrical logging, and geological data, it is possible to fix in advance the volumes of the gas cap and initial oil in place. The water intrusion can then be calculated by inverting Eq. 1 to the form:

$$Z = Q_s u + v(r_p - r_0) + z - (v - v_0)Q_{gi} - (u - u_0)Q_0 \quad [22]$$

When applied in this way the material-balance equation should permit the determination of the water intrusion with the same accuracy the other terms in the equation are known.

Another well-founded application of the material-balance method is its use as a means for extrapolating or predicting the future behavior of a reservoir. For this purpose it is to be assumed that the previous performance has permitted a unique and trustworthy determination of the original basic unknowns, such as the gas-cap volume and the initial oil in place. By fitting the calculated water intrusions from the early performance to a functional representation of the water-intrusion factor, and thus determining the value of the coefficient c, the future history for any assumed operating conditions should be predicted by the material-balance equations with satisfactory accuracy. This type of application may be of particular value in making forecasts of the performance of pressure-maintenance operations.

Conclusions

The study of the material-balance method as reported here leads to the conclusion that by itself the method cannot reliably provide a unique determination of the basic physical characteristics of an oil-producing reservoir. When, however, there are available independently established controlling data, such as the values of the initial oil in place or gas-cap volume, the material-balance equations will provide a useful tool in estimating water intrusion or in predicting future reservoir behavior. With respect to the functional representation of the water-intrusion term, it appears that from a practical point of view all the various formulas that have thus far been proposed will give substantially the same results. Accordingly, any reasonable approximating function should suffice, unless its use reveals internal inconsistencies or other obvious failures in representing the water intrusion.

Acknowledgments

The authors are indebted to members of the Production Department of the Tulsa Division of the Gulf Oil Corporation for assistance in the calculations.

Acknowledgment is made to Mr. S. G. Sanderson, Gulf Oil Corporation, for encouragement in the work; to Mr. J. P. Wible, Gulf Oil Corporation, for helpful criticism of the paper; and to the manage-

ment of the Gulf Oil Corporation for permission to publish the paper.

Nomenclature

Q_0, stock-tank oil originally in place, bbl.
Q_s, stock-tank oil produced, bbl.
Q_{gi}, original volume of gas cap, cu. ft., at 60°F. and 14.7 lb. per sq. in. abs.
Q_a, apparent volume of stock oil in place, bbl., obtained from material-balance data when gas cap and water influx are neglected.
u, volume of oil and originally dissolved gas in reservoir, per volume of stock-tank oil.
u_0, value of u at initial reservoir conditions.
r_p, cumulative net produced gas-oil ratio, cu. ft. per bbl., at 60°F. and 14.7 lb. per sq. in. abs.
r_0, originally dissolved gas-oil ratio, cu. ft. per bbl.
v, reservoir volume of one cubic foot of gas at standard conditions, bbl.
v_0, value of v at initial conditions.
z, cumulative water production, bbl.
Z, cumulative water encroachment, bbl.
p, reservoir pressure, lb. per sq. in.
Δp, decline in reservoir pressure from original reservoir pressure, lb. per sq. in.
t, time elapsed since initial production began.

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Prediction of Conditions for Hydrate Formation in Natural Gases

By Donald L. Katz,* Member A.I.M.E.

(New York Meeting, February 1944)

Abstract

Charts for predicting the pressure to which natural gases may be expanded without hydrate formation have been prepared for gases of even gravity. Pressure-temperature curves for hydrate formation were established for gases having gravities from 0.6 to 1.0. These curves and the thermal behavior of the gases during free and adiabatic expansion were used to prepare the charts for estimating the permissible expansion of natural gases without hydrate formation.

Table 1.—*Typical Compositions of Natural Gases Corresponding to Gas Gravities*

Calculated gas gravity	0.603	0.704	0.803	0.906	1.023
Constituent	Mol Fractions				
Methane	0.9267	0.8605	0.7350	0.6198	0.5471
Ethane	0.0529	0.0606	0.1340	0.1777	0.1745
Propane	0.0138	0.0339	0.0690	0.1118	0.1330
i-butane	0.00182	0.0084	0.0080	0.0150	0.0210
n-butane	0.00338	0.0136	0.0240	0.0414	0.0640
Pentanes plus	0.0014	0.0230	0.0300	0.0343	0.0604
Pressure of hydrate formation at 50°F., lb. per sq. in. abs.:					
Calculated	462	323	254	203	191
Smooth curve, Fig. 1	450	318	261	220	189

The problem was solved by L. F. Albright, W. T. Boyd, J. J. McKetta, G. Martin, F. Poettman, and A. P. Snyder, who are first-year graduate students in the department of Chemical and Metallurgical Engineering at the University of Michigan. This paper is essentially a summary of their results.

Manuscript received at the office of the Institute Feb. 15, 1944. Issued as T.P. 1748 in Petroleum Technology, July 1944.

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Prediction of Conditions for Hydrate Formation in Natural Gases

Each natural gas under a given pressure will form solid hydrates at a corresponding temperature provided sufficient water is present.[1–5] The temperature of natural gases below about 5000 lb. per sq. in. decreases when the gases are expanded freely.[6,7] This decrease in temperature may cause the expanding gas to enter the region of temperature and pressure at which hydrates will form. The final pressure to which a natural gas may be expanded without hydrate formation depends upon the initial temperature and pressure and the gas composition.

This paper presents charts that give the final pressures to which gases of gravity 0.6 to 1.0 at given initial temperatures and pressures may be expanded without formation of hydrate.

Hydrate-forming Temperatures and Pressures as a Function of Gas Gravity

Experimental data of pressure versus temperature at which solid hydrate will form, provided sufficient water is present, are available for a series of gases.[2,3] A method of predicting the pressure-temperature curve for a given gas composition has been reported.[1] The solution to this problem requires that these curves relating pressure to temperature be established for gases of given gravities.

[1] References are at the end of the paper.

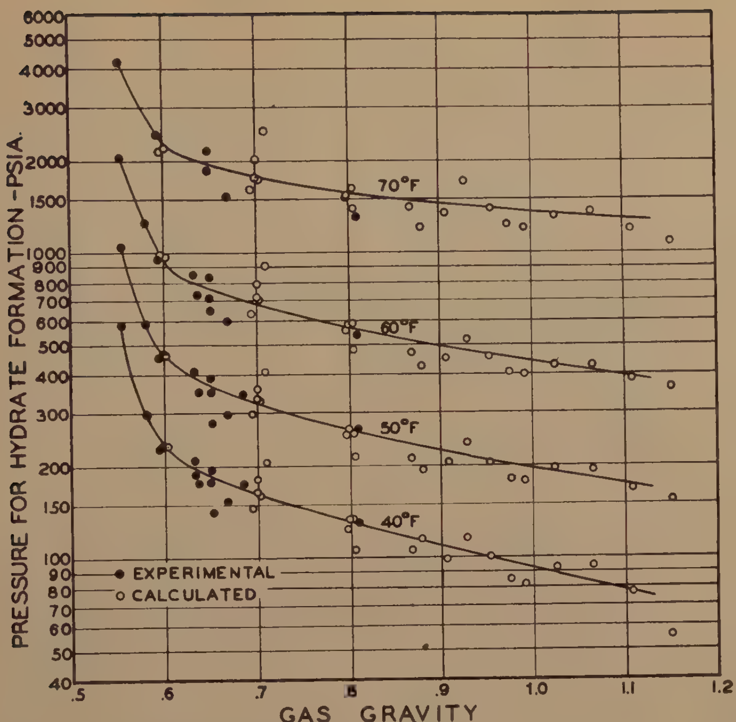

FIG. 1.—HYDRATE PRESSURE-TEMPERATURE RELATIONS AS A FUNCTION OF GAS GRAVITY.

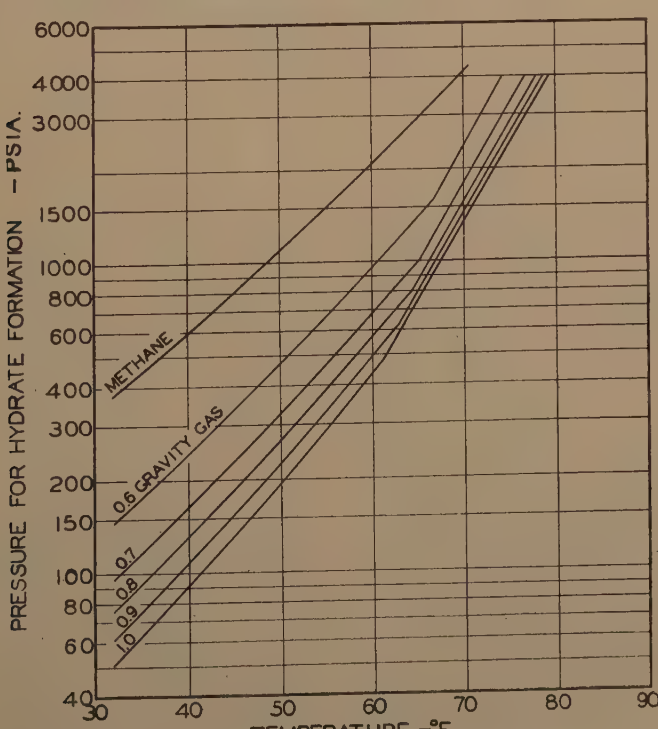

FIG. 2.—PRESSURE-TEMPERATURE CURVES FOR PREDICTING HYDRATE FORMATION.

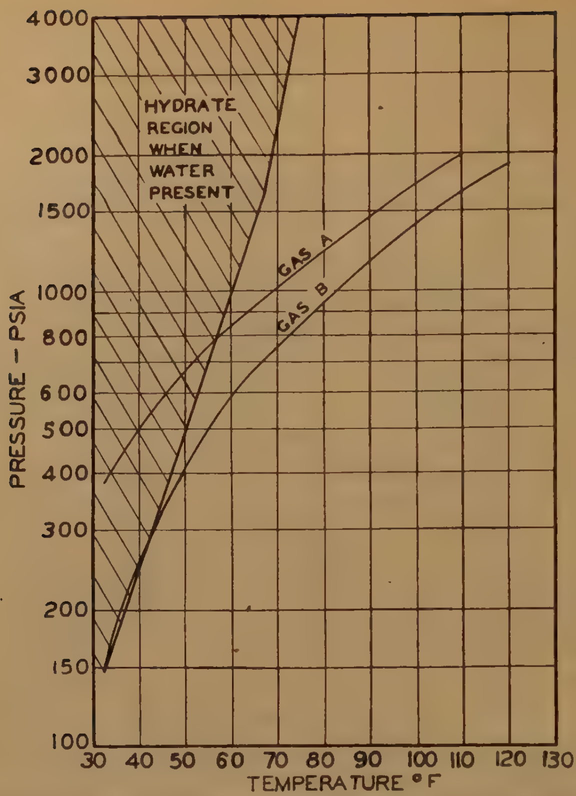

FIG. 3.—INTERSECTION OF FREE EXPANSION CURVES WITH HYDRATE FORMATION REGION FOR 0.6 GRAVITY GASES.

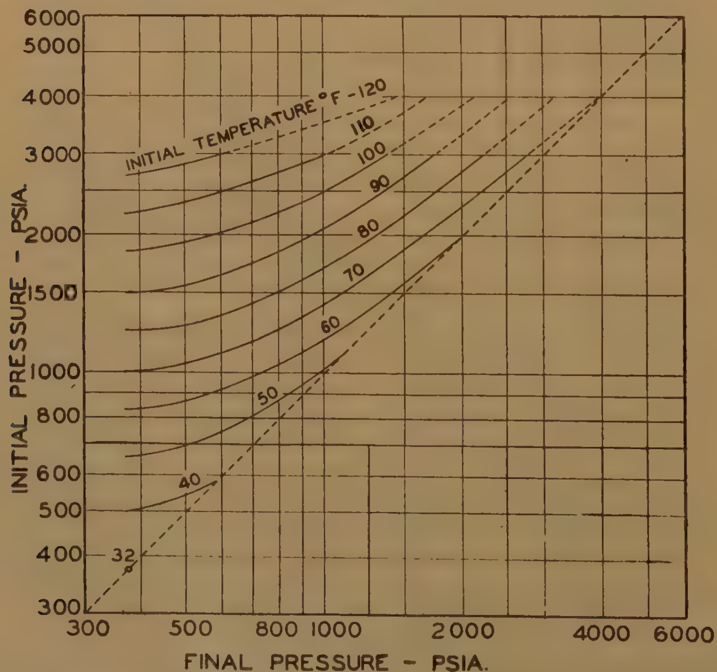

FIG. 4.—PERMISSIBLE EXPANSION OF METHANE WITHOUT HYDRATE FORMATION.

Compositions of typical natural gases were selected to cover the gravity range from 0.6 to 1.0. The pressures at which hydrate would form at 40°, 50°, 60°, and straight-line section at the high pressure. The curves were terminated at 4000 lb. per sq. in., since the nature of the curves at higher pressures is not known.

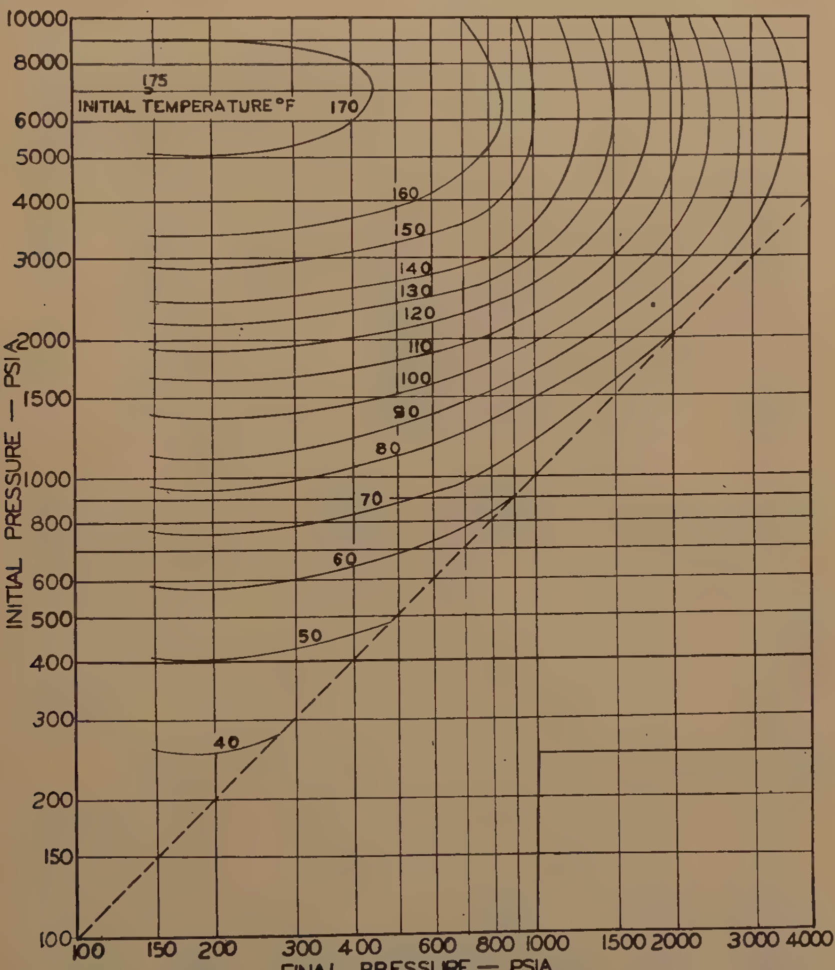

FIG. 5.—PERMISSIBLE EXPANSION OF A 0.6 GRAVITY NATURAL GAS WITHOUT HYDRATE FORMATION.

70°F. were computed, using vapor-solid equilibrium constants.[1] The results of these calculations, along with the experimental data,[2,3] were plotted on Fig. 1, using gas gravity to represent composition.[8,9] From the smooth curves on Fig. 1, the curves of Fig. 2 were drawn, using the experimental curves[2] as a guide for the

As there was considerable variation between the points and the curves drawn on Fig. 1, the compositions of some natural gases represented by the hydrate curves on Fig. 2 for a given gravity are tabulated in Table 1. Only natural gases having compositions similar to these are represented by the curves of Fig. 2.

Charts for Predicting Permissible Expansion of Natural Gases without Hydrate Formation

The curves of Fig. 2 are the minimum temperatures at corresponding pressures until this expansion curve reaches the hydrate-formation curve of Fig. 2.

The enthalpy-entropy charts described by G. G. Brown[6,7] provide the relationship of temperature versus pressure for gases

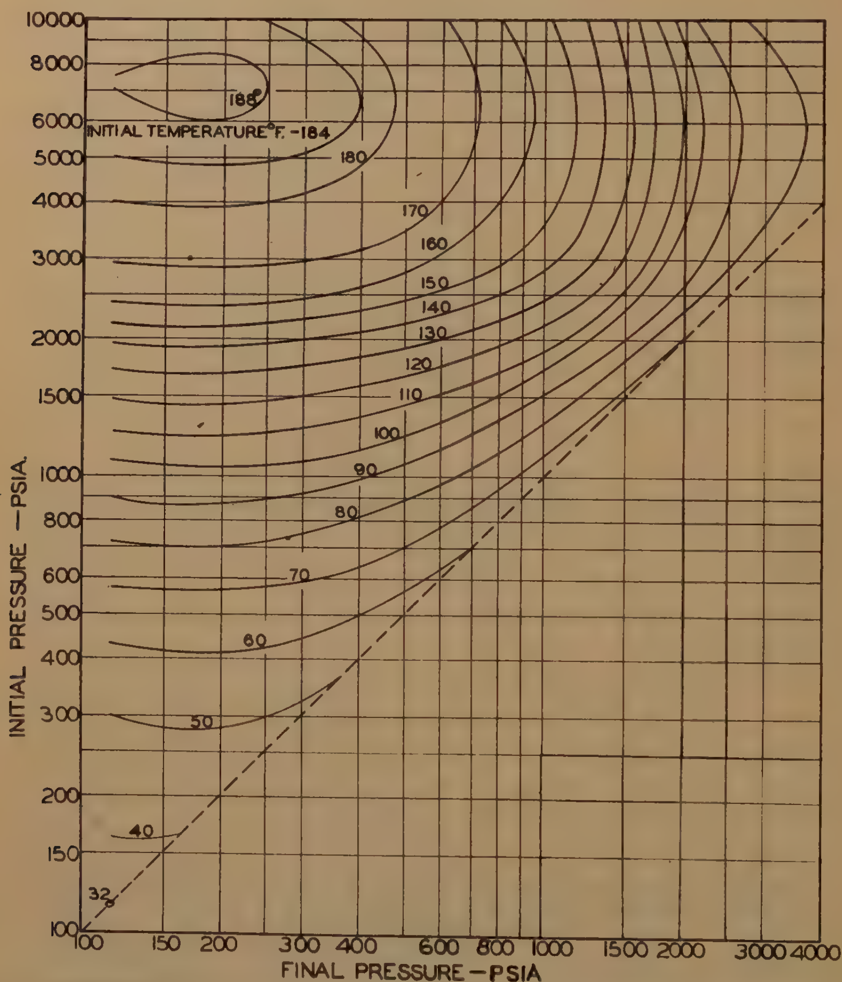

Fig. 6.—Permissible expansion of a 0.7 gravity natural gas without hydrate formation.

to which a given gas may be cooled by expansion, or otherwise, without hydrate formation. A gas under specified initial temperature and pressure may be expanded freely, decreasing temperatures corresponding to decreasing pressures, of even gravities by following constant enthalpy lines for free expansion. Fig. 3 gives the pressure-temperature curves when expanding a 0.6 gravity gas from 2000 lb. per sq. in. and 110°F. (*A*) and from 1900 lb. per sq. in. and 120°F. (*B*).

The intersection of these curves with the hydrate-formation curve taken from Fig. 2 is the final pressure to which the gases may be expanded without hydrate formation.

tionships for pure methane while Figs. 5 through 9 are for the natural gases of given gravity.

The enthalpy-entropy information for methane was limited to 3000 lb.,[10] hence

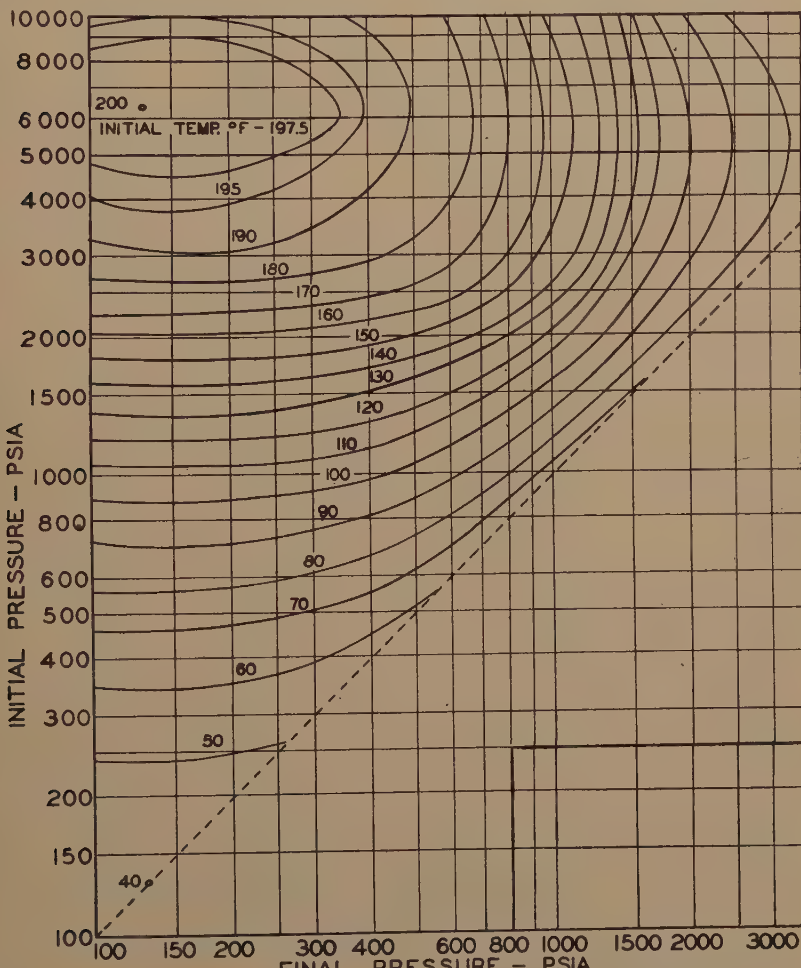

Fig. 7.—Permissible expansion of an 0.8 gravity natural gas without hydrate formation.

Using the enthalpy-entropy charts[7] and the curves from Fig. 2, charts were constructed giving a complete range of initial pressures and temperatures with corresponding final pressures to which the gases may be expanded freely without hydrate formation. Fig. 4 gives the relationships for pure methane while Figs. 5 through 9 are for the natural gases of given gravity.

this chart does not go to the 10,000-lb. initial pressure used for the natural gases.

Errors in constructing the charts were located by cross-plotting the final pressures to which the gases could be expanded as a function of gas gravity for a series of initial pressures. The cross plot for a

2000-lb. initial pressure is given by Fig. 10.

The reversal in the curves at high final pressures on Figs. 5 through 9 occurs because the temperature of natural gases increases on free expansion from above 5000 to 6000 lb. per sq. in. and then decreases after reaching pressures in this range. This pressure at which gases decrease in temperature depends upon the compressibility-factor curves. Where the rate of change of the compressibility factor with temperature is positive, the gas decreases in temperature upon expansion, and where the rate of change is negative, the gas increases in temperature upon free expansion.

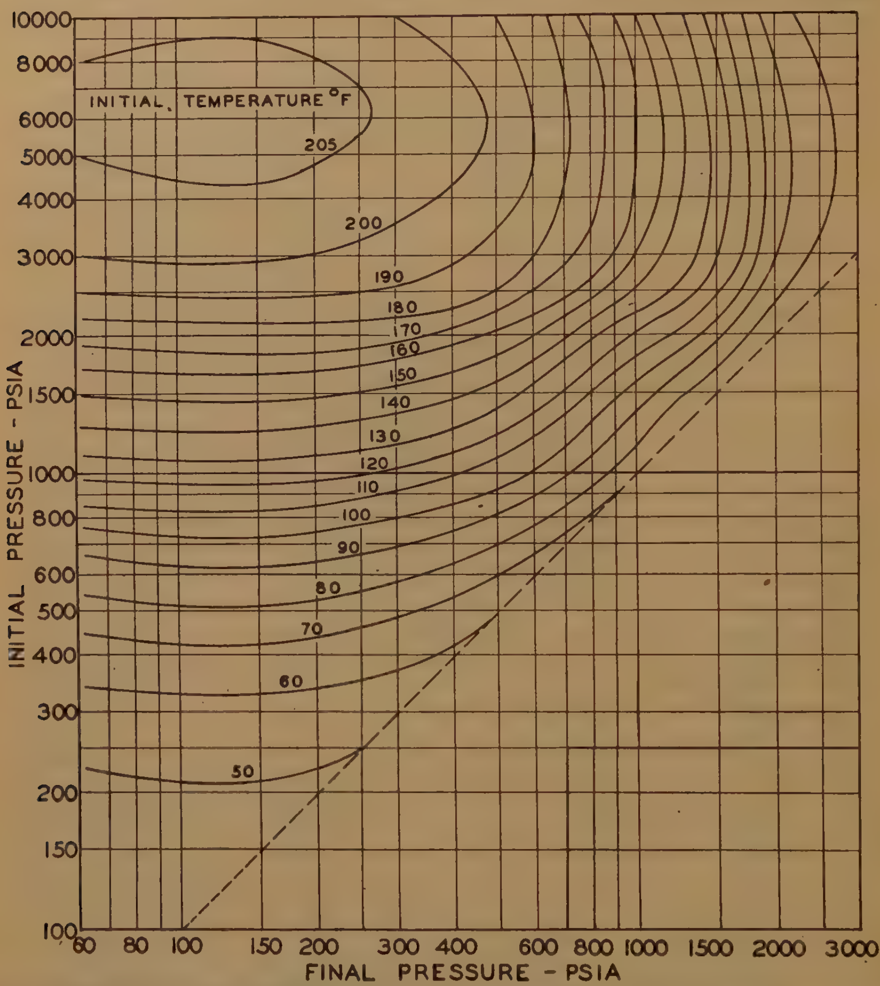

FIG. 8.—PERMISSIBLE EXPANSION OF A 0.9 GRAVITY NATURAL GAS WITHOUT HYDRATE FORMATION.

The slight curvature of the initial temperature curves at low final pressures is due to the exit of the free expansion curve from the hydrate-formation region as illustrated by curve *B* of Fig. 3. When two alternative final pressures are given for an initial pressure and temperature, the

final pressure after expansion without hydrate formation may be the higher pressure as a minimum and the lower pressure as a maximum.

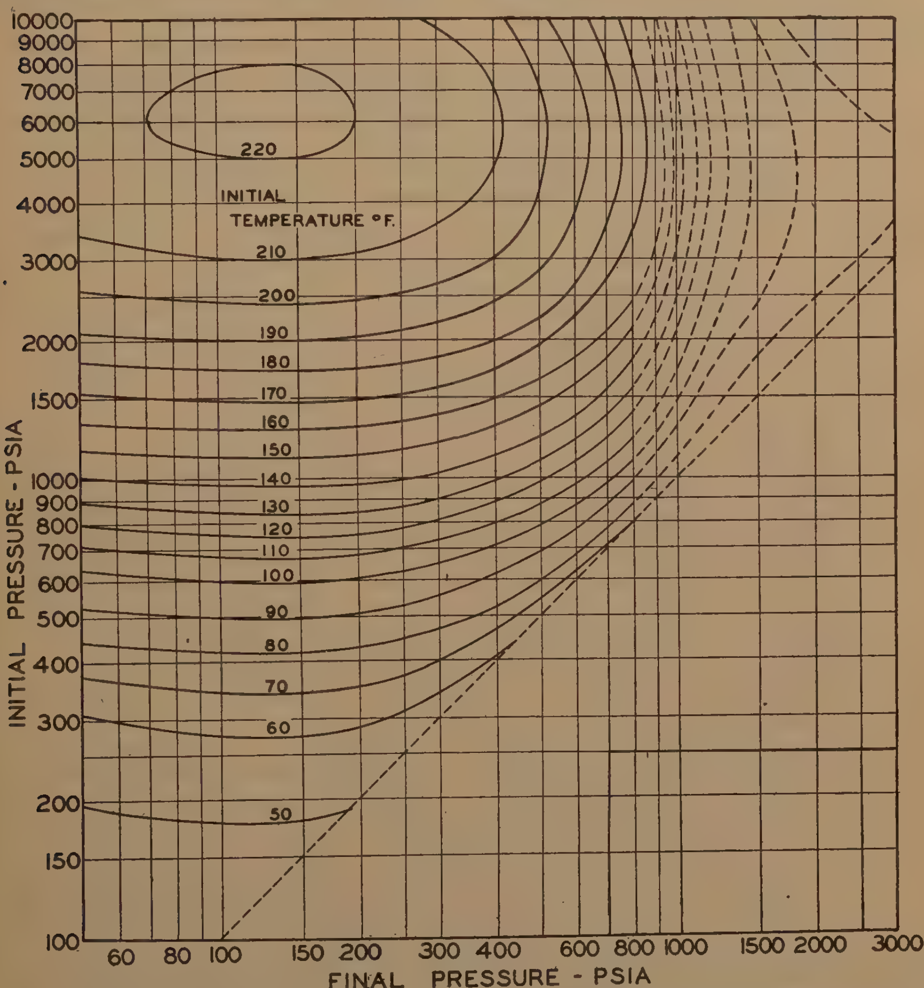

FIG. 9.—PERMISSIBLE EXPANSION OF A 1.0 GRAVITY NATURAL GAS WITHOUT HYDRATE FORMATION.

USES OF THE CHARTS

Fig. 4 through 9 may be used to solve two types of problems, with examples as follows:

1. How far may a 0.6 gravity gas at 2000 lb. pressure and 100°F. be expanded without danger of hydrate formation? The answer, from Fig. 5, is 1050 lb. per sq. in. absolute.

2. How far may a 0.6 gravity gas at 2000 lb. and 140°F. be expanded without hydrate formation? The answer, from Fig. 5, is that hydrates will not form upon expansion to atmospheric pressure.

3. A 0.6 gravity gas is to be expanded from 1500 lb. to 500 lb. What is the minimum initial temperature that will permit the expansion without danger of hydrates? The answer, from Fig. 5, is an initial temperature of 99°F. or above.

4. A 0.6 gravity gas at 10,000 lb. and 140°F. is expanded freely and adiabatically:

a. At what lower pressure will the temperature become 140°F.?

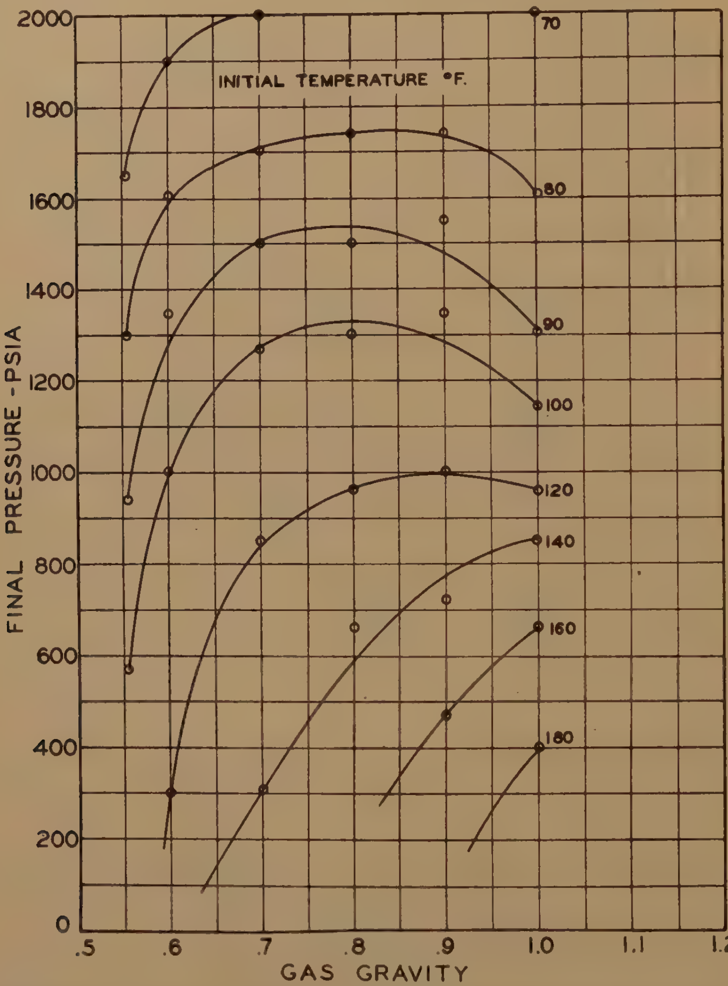

FIG. 10.—CROSS PLOT OF FIGS. 4 THROUGH 9 AT 2000 POUNDS PER SQUARE INCH ABSOLUTE INITIAL PRESSURE.

b. At what pressure would hydrates be likely to appear if sufficient water is present?

The answer, from Fig. 5, is (*a*) 4300 lb. and (*b*) 1150 pounds.

Similar problems may be solved for gases of other gravities with interpolation between charts when necessary.

A word of caution should be given that the charts are valid only for gases having similar compositions for the gravities corresponding to those of Table 1. The expansions described are always free and adiabatic. Hydrates will form only when sufficient (usually liquid) water is present, and the charts do not apply to anhydrous natural gases.

ACKNOWLEDGMENT

The cooperation of the Graduate Students in the preparation of this paper and

in the construction of the figures is appreciated.

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Experimental Determinations of Water Vapor Content of a Natural Gas Up to 2000 Pounds Pressure

By George F. Russell,* Robert Thompson,† Frank P. Vance,‡ Junior Member, and R. L. Huntington,* Member A.I.M.E.

(Houston Meeting, May 1944)

Abstract

With the advent of higher pressures in the operation of natural-gas transmission lines, the removal of water vapor from the gas has become increasingly important in order to prevent condensation or formation of gas hydrate from slowing down or stopping the flow of gas. Intelligent design of these dehydration or gas-drying plants has been hampered through the lack of experimental data on the water-vapor content of natural gas at elevated pressures. In view of this need, this present investigation was sponsored by the Southern Natural Gas Co. in the Chemical Engineering laboratories at the University of Oklahoma Research Institute. Experimental results were obtained on the water-vapor content of natural gas up to 2000 lb. per sq. in. at atmospheric temperatures. The water content at 2000 lb. is approximately two thirds as much as it is at 1000 lb. Deviations from the ideal gas laws vary directly with pressure and indirectly with temperature.

Introduction

The removal of water vapor from natural gas is an important operation in connection with the production and transportation of this commodity because:

1. Liquid water accelerates internal corrosion of a pipe line.

2. Accumulation of water at low points in a pipe line reduces markedly its capacity.

3. Gas hydrates, icy snowlike growths, form readily under high pressure in the presence of the lower hydrocarbons and water, often plugging up the pipe line.

In order to design dehydration plants for stripping the gas of its water content, it is essential that the engineer have a knowledge of the saturated or equilibrium water-vapor content of the gas to be processed. With the gradual increase of operating pressures around gas-producing wells and pipe lines, it was observed that the quantity of water recovered from dehydration plants or condensed in colder lines was considerably greater than had been expected from calculated contents, based on vapor-pressure data taken from steam tables.

This observation prompted a number of investigators, for instance, Laulhere,[3] Deaton,[1] and Hammerschmidt[2] to carry out experimental work at pressures up to 600 lb. per sq. in. in order to determine quantitatively the water content of various gases. Sage, Lacey, et al.[4,5] have recognized more recently the need for such data at higher pressures, but their work was done at temperatures of 100°F. and higher. Since hydrate formation usually, if not entirely, occurs at temperatures below 100°F., the present investigation was confined to the lower temperature range at pressures from 600 to 2000 lb. per sq. in. gauge.

Manuscript received at the office of the Institute July 21, 1944. Issued as T.P. 1792 in Petroleum Technology, January 1945.

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[1] References are at the end of the paper.

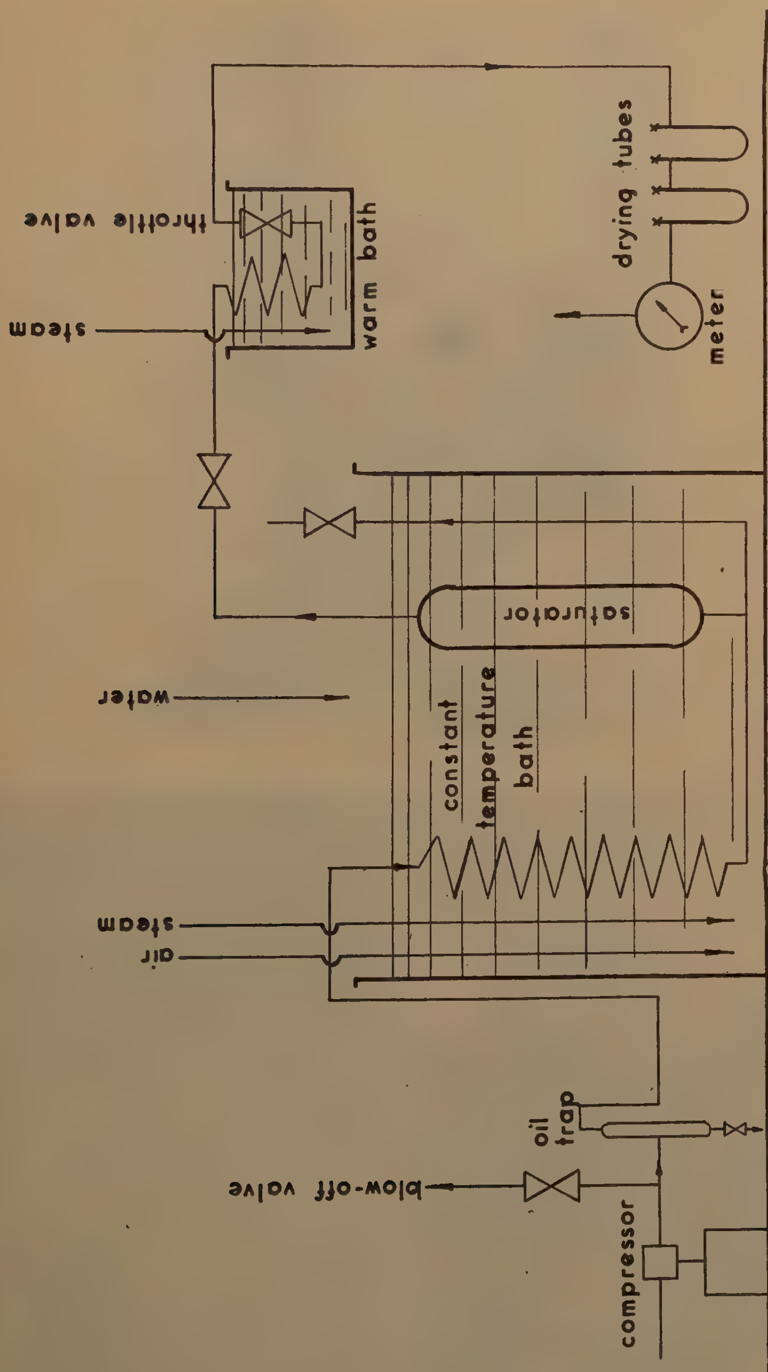

FIG. 1.—FLOWSHEET OF APPARATUS FOR DETERMINING WATER CONTENT.

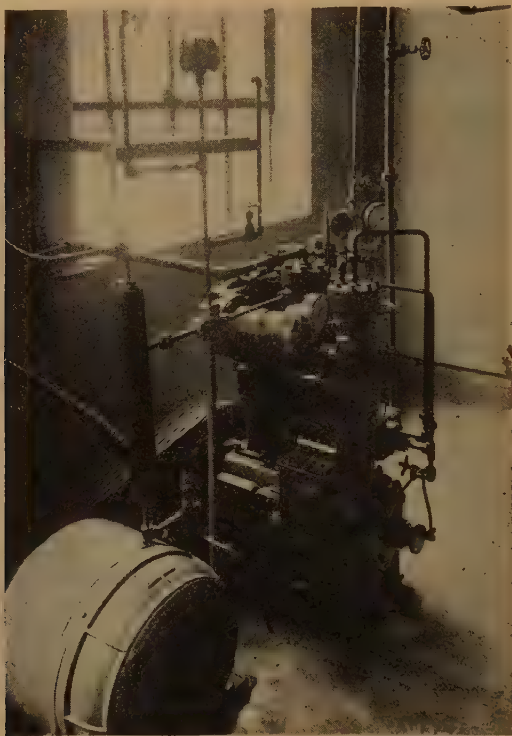

FIG. 2.—THREE-STAGE GAS COMPRESSOR.

FIG. 3.—THERMOSTATIC BATH CONTAINING SATURATOR.

Experimental Apparatus, Materials and Procedure

The natural gas used throughout the investigation, was obtained from the mains saturator packed with fine-grained Ottawa sand in a constant-temperature bath followed by a superheater and expansion valve. The second section was the water-

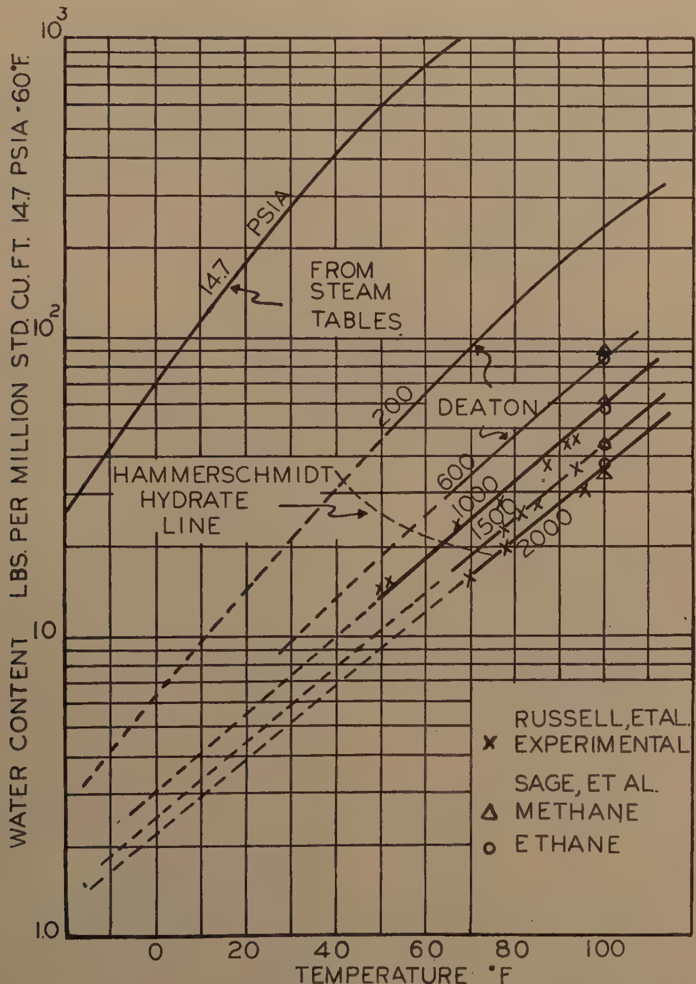

Fig. 4.—Water content as a function of temperature at indicated constant pressures.

of the Oklahoma Natural Gas Co. Its composition, determined by means of the Orsat and low-temperature fractional analyses, was as shown in the accompanying table.

The apparatus used for the determination of saturated water-vapor content of high-pressure natural gas consisted of two sections. The first section was the water

Component	Mol or Volume, Per cent
Carbon dioxide	0.60
Nitrogen	1.00
Methane	94.36
Ethane	2.64
Propane	0.96
Butanes plus	0.44

absorption system followed by a wet test-meter for measuring the gas volume passed.

The temperature of the saturator was maintained within ±0.5°F. by circulating water in a bath and agitating with air. This control was aided by the maintenance of a constant room temperature approximately 10°F. above that of the saturator. By having an elevated room temperature, water condensation in exposed lines was prevented. A flow diagram (Fig. 1) and two photographs (Figs. 2 and 3) of the experimental system are self-explanatory. The system pressure was manually controlled within ±5 lb. per sq. in., and proved with a dead-weight tester.

In determining the water-vapor content of high-pressure natural gas, the conventional drying tube method was used. This method simply employs a highly hygroscopic sorbing agent (anhydrous magnesium perchlorate) to remove substantially all the water vapor from a known volume of gas. The increase in weight of the drying tubes per standard cubic foot of dry gas was taken as the quantity of water present.

To ensure practically complete removal of all water vapor present, two U-tubes were used in series. The gas was passed through the train at a constant rate of 6 std. cu. ft. per hour. It was found that this

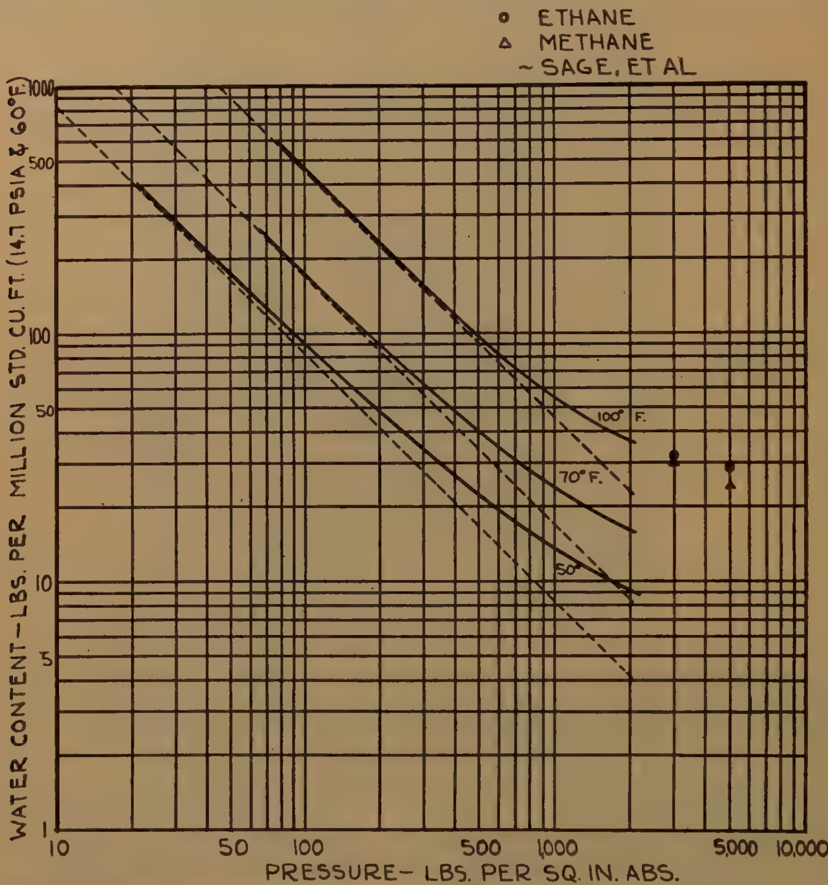

FIG. 5.—WATER CONTENT VERSUS PRESSURE AT INDICATED CONSTANT TEMPERATURES. Broken lines calculated from vapor pressure of water, assuming ideal gases.

rate was the maximum allowable if the first drying tube was to retain 95 per cent or more of the total water removed from at temperatures between the hydrate line and 100°F. were made. It is to be noted that the minimum temperature was fixed

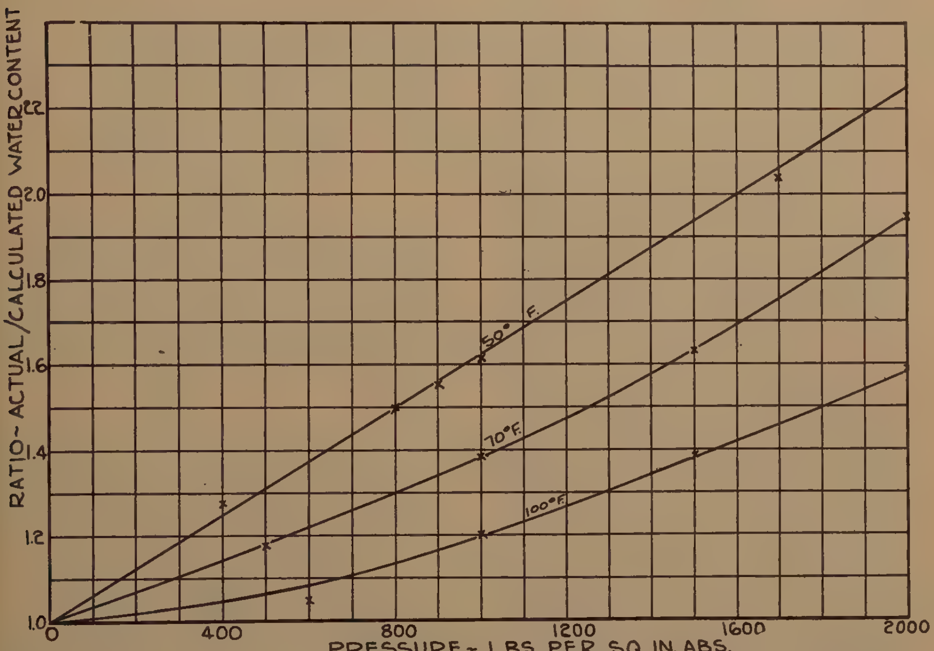

FIG. 6.—RATIO OF ACTUAL TO CALCULATED WATER CONTENT AS A FUNCTION OF PRESSURE AT INDICATED CONSTANT TEMPERATURES.

the gas. The criterion for complete water extraction was that the second, or scavenging, tube should not increase in weight more than 5 per cent as much as the first tube. To prevent hydrocarbon adsorption during the tests, the drying tubes were saturated with hydrocarbons by purging the train with natural gas before each test.

The length of time required for each series of check determinations was from 2 to 3 hr., during which 12 to 18 std. cu. ft. of gas were passed. During this time the room temperature, as well as the saturator temperature, was held constant. This constant room temperature was necessary to make discrepancies in gas-meter volume correction as low as possible.

To establish at constant pressure the trend of water-vapor content with change in temperature, several evenly spaced tests

TABLE 1.—*Experimental Data*

Barometric Pressure = 14.1 Pounds per Square Inch Absolute

Gauge Pressure, Lb.	Temperature, Deg. F.	Water Content[a]
1000	50	14.3
1000	51	15.1
1000	66	23.1
1000	76	27.5
1000	86	38.3
1000	91	44.1
1000	93	45.2
1500	60	14.5
1500	78	22.1
1500	81	25.5
1500	85	27.3
1500	93	36.8
2000	70	15.6
2000	78	20.0
2000	95	31.6

[a] The water contents shown represent the arithmetic average of four separate determinations, which were made at the same temperature and pressure. They are expressed as pounds of water vapor associated with 1,000,000 cu. ft. of bone-dry gas when measured at 60°F. and 14.7 lb. per sq. in. absolute.

by the complete freezing up of the system, through which no gas would pass. To prove that equilibrium was definitely established in the saturator, several trial runs were made in which the inlet gas was undersaturated and oversaturated with water. No change in the outlet, or equilibrium, gas was detected.

For the maintenance of a steady flow through the system, the water-saturated gas was heated to 210°F. before it was allowed to expand to atmospheric pressure. This successfully prevented the formation of gas hydrates in the expansion valve.

Experimental data are given in Table 1.

Discussion of Results

A plot (Fig. 4) of the logarithm of water content versus temperature gives substantially straight lines for constant pressures from 1000 to 2000 lb. per sq. in. The lines are based upon data obtained during this investigation, as well as those from Deaton[1] and Sage et al.[4,5] The calculated curve from the vapor-pressure data on water holds true for lower pressures.

A cross plot of Fig. 4 is shown in Fig. 5, in order to give a picture of the deviation, upon changing temperature and pressure, of the actual water content from values as calculated from the vapor pressure of water and assuming ideal gases.

The ratio of actual to calculated water content is shown in a different manner in Fig. 6. This plot clearly shows that the deviation from the ideal increases with a decrease in temperature. Deaton found that the water content in the presence of helium was not affected by pressure.

Acknowledgment

The authors wish to express their appreciation to the Southern Natural Gas Co., whose management sponsored this research through the Oklahoma Research Institute, at the University of Oklahoma.

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Fractional Analysis of Well Effluents to Trace Migration of High-pressure Reservoir Gas

By E. P. Valby*

(Los Angeles Meeting, October 1944)

Abstract

A method is presented in which the hydrocarbon weight fractional analyses of the well effluents from a true gas-cap-portion well and a true dark-oil-ring well furnish the basic data for determining the properties of any mixture of production from the two sources. The effect of injected gas on these properties can be computed. Comparison of similar properties of a given well effluent to the properties of mixtures of the basic well effluents will give the relative amounts of production from the two sources and injected gas.

Presentation of Problem

Oil fields having an area of gas-cap, or light-oil production, over the dark-oil area present a problem of increasing gas-oil ratios during the production of an oil well. The use of pressure maintenance in a field such as above, or a cycling project, wherein residue gas from an absorption plant is injected into the reservoir, adds to the problem, because a part of the increased gas-oil ratio may be due to the production of injected gas. The usefulness of a means to determine the amount of injected gas in a well effluent led to the development of a method in which well-effluent analyses of a true gas-cap-portion well and a true dark-oil-ring well furnish the basic data needed to determine whether injected gas of a known composition is present in a given well effluent.

Development of Method

The method presented herein is based upon the principle that if two fluids, or well effluents, having different properties are mixed in known proportions by weight, the properties of their mixtures can be computed. Conversely, if these basic data are known, the properties of a mixed well effluent can be used to compute the relative amounts of each type of well effluent in the mixture. A convenient way of making these computations is to have the fractional analyses of the base well effluents and mixtures expressed in weight fractions. The mathematical equations expressing the properties of mixtures will be developed for a two-component system consisting of the well effluents from the dark-oil ring and the gas-cap area. The added effect of injected gas, a third component, will also be developed.

The following assumptions have been made in developing the method:

1. The gas-cap and dark-oil fluids exist initially in separate portions of the reservoir.

2. The fluids in each portion exist in a single phase at pressures above the saturation pressure for the dark-oil fluid.

3. The composition of each fluid is substantially constant throughout its respective portion of the reservoir.

4. Changes in reservoir pressure and temperature will not change the composition of the fluid entering the well bore.

5. The injected gas displaces original gas-cap fluid 100 per cent.

6. As the injected gas travels through a

Manuscript received at the office of the Institute Nov. 15, 1944. Issued as T.P. 1873 in Petroleum Technology, July 1945.

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reservoir to reach a well bore, any enrichment that occurs will be from the contacted fluid as a whole.

7. The liquid volumes are additive when the isobutane and heavier hydrocarbons from the gas-cap and dark-oil fluids are mixed.

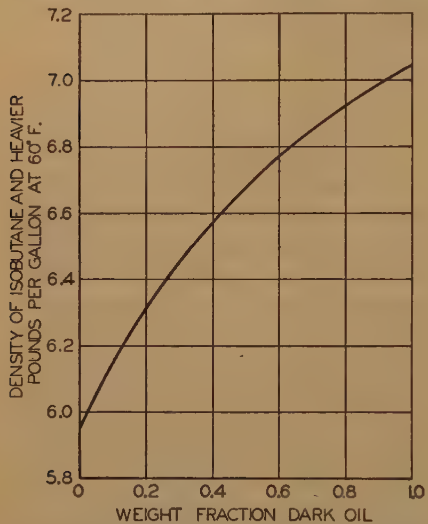

FIG. 1.—WEIGHT FRACTION OF DARK OIL IN WELL EFFLUENT FROM DENSITY OF ISOBUTANE AND HEAVIER.

For the purpose of deriving this method, the weight-fraction analysis of the effluent has been divided into two portions—propane and lighter, and isobutane and heavier, since the present-day absorption plants are recovering high percentages of the isobutane and normal butane in the gases being treated. Certain specific properties of these portions are determined by calculation: For the propane and lighter, the volume in cubic feet at 14.73 lb. per sq. in. abs. and 60°F. contained in 100 lb. of well effluent; and for the isobutane and heavier, its density in pounds per gallon at 60°F.

From the weight-fraction analyses and the properties of the portions of the well effluents from the two sources of production, dark oil and gas cap, certain equations can be developed, by which it is possible to compute the composition of a mixed well effluent.

In one pound of a mixed well effluent there will be:*

A, pounds of dark oil-well effluent and,

B, $1 - A$ = pounds of gas-cap well effluent.

Then the pounds of isobutane and heavier in one pound of mixture, and also its weight fraction, can be found from

$$I_m = I_1A + I_2(1 - A) \qquad [1]$$

Also, the gallons of isobutane and heavier in one pound of mixture can be found from

$$G_m = I_1A/D_1 + I_2(1 - A)/D_2 \qquad [2]$$

Dividing Eq. 1 by Eq. 2 will then give the density of the isobutane and heavier in the well-effluent mixture:

$$D_m = \frac{I_m}{G_m} = \frac{I_1A + I_2(1 - A)}{AI_1/D_1 + (1 - A)I_2/D_2} \qquad [3]$$

If D_m of the well effluent is known and A is sought, Eq. 3 can be solved for

$$A = \frac{D_mI_2/D_2 - I_2}{I_1 - I_2 - D_m(I_1/D_1 - I_2/D_2)} \qquad [4]$$

Thus it is possible to determine the proportion of dark-oil and gas-cap fluids that are present in any well effluent from the density of the isobutane and heavier.

If gas is being injected into the reservoir, it is necessary at this point in the computations to determine whether injected gas is present in the well effluent. The effect of injected gas is that of dilution, since in most cases the injected gas contains only small amounts of isobutane and heavier. If A, as found from Eq. 4, is used in Eq. 1, the expected weight fraction of isobutane and heavier in the mixture can be computed. If this computed value is equal to that determined by well-effluent analysis,

* Nomenclature at the end of the paper.

injected gas is not present. Eq. 1 can then be used to solve for

$$A = \frac{I_m - I_2}{I_1 - I_2} \quad [5]$$

Thus, where injected gas is not present, Eq. 5 is used to determine the proportions of dark-oil and gas-cap reservoir fluids in the well effluent.

It would be of more practical use if the relative amounts of wet gas produced from each source could be determined. This can be approximated from the propane and lighter fractions of the two sources of production. The volumes of propane and lighter from each source can be computed from

$$Q_m = Q_1 A + Q_2(1 - A) \quad [6]$$

The volume percentages of propane and lighter for each source can then be computed and used to distribute the wet gas produced by the well. This distribution of wet gas will be an approximation only, as the separating conditions will control this distribution.

Determination of Injected Gas

If the computed value of I_m from Eq. 1, using the value of A from Eq. 4, is greater than that determined by well-effluent analysis, injected gas is present. If no isobutane and heavier is in the injected gas, the weight fraction of injected gas can be computed from

$$Y = 1 - \frac{I_m}{I_1 A + I_2(1 - A)} \quad [7]$$

However, since isobutane and heavier is present in most injected gases, Eq. 7 must be modified. In this development the mixture of dark-oil and gas-cap effluents will be treated as a single component, X, in the following equations:

$$X + Y = 1 \quad [8]$$

Eq. 1 then becomes

$$I_m = I_1 AX + I_2(1 - A)X + I_3 Y, \quad [9]$$

and substituting $X = 1 - Y$,
and solving,

$$Y = \frac{(I_1 - I_2)A + I_2 - I_m}{(I_1 - I_2)A + I_2 - I_3} \quad [10]$$

The value of I_m is that found from the well-effluent analysis and A by Eq. 12 as developed later.

Further, Eqs. 2 and 3 would also be modified, resulting in equation

$$D_m = \frac{I_1 AX + I_2(1 - A)X + I_3 Y}{AXI_1/D_1 + (1 - A)XI_2/D_2 + YI_3/D_3} \quad [11]$$

Since D_m has been determined from the well-effluent analysis, and A is required, Eq. 11 can be solved for

$$A = \frac{D_m I_2/D_2 - I_2 - Y[D_m(I_2/D_2 - I_3/D_3) - I_2 + I_3]}{(1 - Y)[I_1 - I_2 - D_m(I_1/D_1 - I_2/D_2)]} \quad [12]$$

Eqs. 10 and 12 may now be solved by successive approximations for both Y and A, starting with the value of A from Eq. 4. The composition of the well effluent may then be expressed in terms of these variables:

Injected gas $= Y$ weight fraction [13]
Dark-oil fluid $= A(1 - Y)$ weight fraction [14]
Gas-cap fluid $= (1 - A)(1 - Y)$ weight fraction [15]

As before, it is more practical to use the distribution of the wet gas produced by the well. This can be approximated by using the relative amounts of propane and lighter produced from each source, computed accurately from the following equation:

$$Q_m = Q_1 AX + Q_2(1 - A)X + Q_3 Y \quad [16]$$

When injected gas is being produced, the effect of its stripping action on the crude

oil is added to the equilibrium separation of wet gas and crude oil. This condition makes the distribution of wet gases between the dark-oil and gas-cap sources an approximation, but the volume and percentage of injected gas being produced is accurate. In the course of making the material balances for computing the weight-fraction analysis of the well effluent, the pounds of well effluent and volume of wet gas produced for each barrel of tank oil has been computed. The cubic feet of injected gas produced with each barrel of tank oil is found from the equation

$$\text{I.G.} = WYq_8 \qquad [17]$$

This volume subtracted from the production gas-oil ratio will then give the volume of wet gas produced from the two sources.

$$\text{Wet gas} = r - \text{I.G.} \qquad [18]$$

An approximate distribution of this volume can then be made according to the proportion of the volumes of propane and lighter from the two sources as found from Eq. 16. From these three volumes, injected gas, wet gas from the dark-oil fluid, and wet gas from the gas-cap fluid, the relative amounts by volume of the gas produced from each source can be computed.

Single Reservoir and Injected Gas

When a dark-oil reservoir is being operated under pressure maintenance by injecting gas, or a cycling project is in operation in a distillate field, the equivalent equations for determining the amount of injected gas are as follows:

$$I_m = I_1X + I_3Y \qquad [19]$$

or,

$$I_m = I_1(1 - Y) + I_3Y \qquad [20]$$

Solving for Y,

$$Y = \frac{I_1 - I_m}{I_1 - I_3} \qquad [21]$$

In a manner similar to the above, the gas-oil ratio can be distributed between the dark-oil production and injected gas, or condensate-gas production and cycled gas.

Enrichment of Injected Gas by Contact with Residual Oil

In the development of this method of distributing the well effluent, one of the assumptions made was "(6) As the injected gas travels through reservoir, any enrichment that occurs will be from the contacted fluid as a whole." This is, of course, not strictly true because this enrichment is a process of equilibrium vaporization, which occurs in a continuous manner as the enriched injected gas moves along the sand streaks and comes into contact with the residual oil. This process can be visualized by considering the enrichment to occur in a number of successive steps in which the vapors from one step of enrichment comes in contact with another fresh portion of residual oil. Ultimately, the enriched injected gas will be in equilibrium with the residual oil and should have approximately the composition and properties of the gas-cap fluid. The further steps in this process of enrichment are that fresh injected gas comes into contact with stripped residual oil and finally no appreciable enrichment will occur because the residual oil has been stripped of its components volatile at reservoir conditions.

It appears then that well effluent may be composed of these types of fluid—dark oil, gas cap, enriched injected gas, and injected gas. It is also possible that stripped dark oil may be produced. Since the gas-cap fluid and enriched injected gas can have approximately the same composition and properties, this method will not differentiate between these two types. If only a small amount of injected gas is produced along with a comparatively large amount of a gas-cap type of fluid, which may be composed of enriched injected gas and

gas-cap fluid, this lack of identification is not detrimental because the method does show migration of gas that may represent a serious loss of reservoir energy.

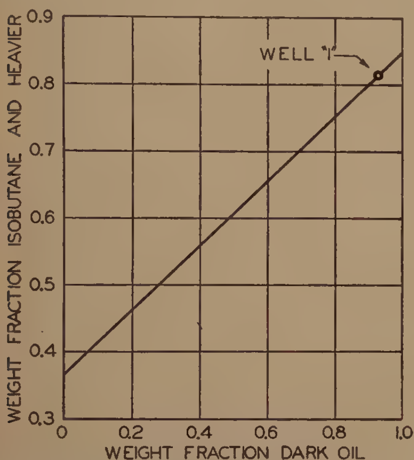

FIG. 2.—WEIGHT FRACTION OF DARK OIL IN WELL EFFLUENT FROM WEIGHT FRACTION OF ISOBUTANE AND HEAVIER.

Conversely, if considerable injected gas is by-passing, its enrichment will be decreasing and would not materially affect this method of determining the amount of injected gas.

Although the enrichment of injected gas does occur, this method will determine the amount of injected gas that is not considered to be enriched and thus help in deciding if remedial work to control the migration of injected gas would be of benefit.

APPLICATION OF METHOD

In order to illustrate the use of this method, data of Dodson and Standing* will be used for the purpose of simulating an oil field having both dark-oil and gas-cap areas of production. Their crude *B* will be used as the dark-oil fluid and their crude *C* will be used as the gas-cap fluid. From the given volume compositions of these two crudes, the weight-fraction analyses of these assumed base fluids can be computed by familiar methods of converting from one type of analysis to

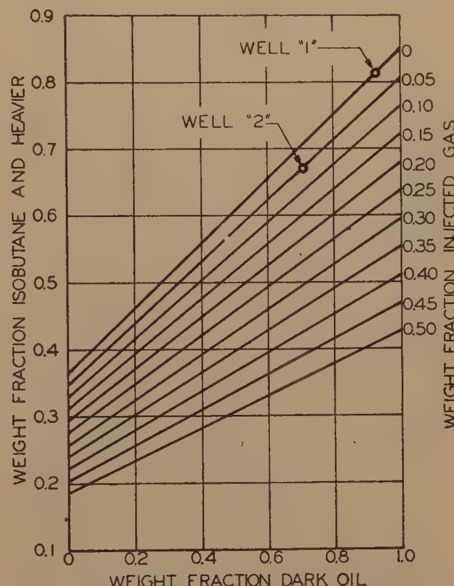

FIG. 3.—WEIGHT FRACTION OF INJECTED GAS FROM WEIGHT FRACTIONS OF DARK OIL AND ISOBUTANE AND HEAVIER IN WELL EFFLUENT.

another. The weight-fraction analysis and properties of certain portions of the dark-oil and gas-cap reservoir fluids and a typical injection gas are given in Table 1.

Substituting these values in the basic equations, the equations pertaining to this assumed field can be developed and used for making well-effluent distributions. The assumed field is taken to be under a pressure-maintenance operation by means of injecting residue gas from an absorption plant, which is extracting substantially all of the isobutane and heavier from the wet gas produced. In Table 2 are given the essential weight-fraction analyses, calculated properties of the two portions of the well effluents, and production data for two wells that have shown an increase in gas-oil ratios.

By use of the equations developed in this paper, the distribution of the well

* G. R. Dodson and M. B. Standing: Prediction of Volumetric and Phase Behavior of Naturally Occurring Hydrocarbon Systems. Amer. Petr. Inst., Drill. and Prod. Practice, 1941 (1942) 326.

TABLE 1.—*Hydrocarbon Analyses and Properties of Dark-oil and Gas-cap Well Effluents*

Component	Dark Oil, Weight Fraction	Gas Cap, Weight Fraction	Injection Gas, Weight Fraction
Methane	0.1034	0.4791	0.7364
Ethane	0.0230	0.0813	0.1446
Propane	0.0249	0.0745	0.1142
Butanes	0.0265	0.0547	0.0048
Pentanes	0.0239	0.0437	
Hexanes	0.0355	0.0426	
Heptanes plus	0.7628	0.2241	
Propane and lighter	0.1513	0.6349	0.9952
Butanes and heavier	0.8487	0.3651	0.0048
Cubic feet propane and lighter per 100 lb. well effluent	294	1,297	2,018
Total volume of gas per 100 lb.			2,021
Density of butanes and heavier, lb. per gal. at 60°F.	7.044	5.951	4.78

TABLE 2.—*Data on Wells Showing Increase in Gas-oil Ratios*

Data	Well No. 1	Well No. 2
Wt. fraction IC_4 plus	0.8126	0.6684
Density IC_4 plus	6.996	6.850
Cubic feet C_3 minus per 100 lb. well effluent	369.3	670
Production gas-oil ratio	1500	3220
Tank-oil gravity, deg. A.P.I.	36.5	38.5
Pounds well effluent per bbl. tank oil	378.4	441.0

effluent for well No. 1 is found to be: 0.9254 weight fraction of dark-oil reservoir fluid and 0.0746 weight fraction of gas-cap reservoir fluid with no injection gas present.

This distribution for well No. 1 is shown on Figs. 2 and 3. The wet gas production is distributed as follows:

Source	Volume, Per Cent	Production, Gas-oil Ratio
From dark oil	73.7	1,106
From gas cap	26.3	394
Total	100.0	1,500

This method thus shows that the increased gas-oil ratio is due to the entry of gas-cap fluid.

In the case of well No. 2, the expected IC_4 plus is greater than that shown by analysis, so injected gas is present. The distribution is computed to be as follows: Dark-oil fluid, 0.6664; gas-cap fluid, 0.2811; and injected gas, 0.0525 weight fractions. This is represented by well No. 2 on Fig. 3. The distribution of the production gas-oil ratio as determined by use of Eqs. 16, 17, and 18 is as follows:

Source	Volume, Per Cent	Production, Gas-oil Ratio
From dark oil	29.9	962
From gas cap	55.6	1,790
From injection gas	14.5	468
Total	100.0	3,220

The well-effluent-analysis method applied to well No. 2 shows that the entry of gas-cap fluid is the primary cause of the increased gas-oil ratio. Injected gas is being produced, however, and no doubt would be an important factor in deciding whether remedial work should be undertaken.

Conclusion

This method has been developed to enable petroleum engineers to follow the movement of injected gas in pressure maintenance or cycling operations. Periodic surveys made by this method will indicate the trend of the operations and materially assist in controlling the dilution of wet gases being processed by absorption plants.

Acknowledgments

The author wishes to thank Mr. L. E. Porter, Assistant Manager of the Exploitation Department, Richfield Oil Corporation, for permission to publish this paper.

Acknowledgment is gratefully made to Mr. H. R. Linhoff, Manager of the Natural Gasoline and Gas Operations, Richfield Oil Corporation, for encouraging the development of this method.

Nomenclature

- *A* Pounds of dark-oil fluid in one pound of well effluent; also equals its weight fraction.
- *B* Pounds of gas-cap fluid in one pound of well-effluent mixture; also equals its weight fraction.
- *D* Density of isobutane and heavier in well effluent—pounds per gallon at 60°F.
- *G* Gallons of isobutane and heavier in one pound of well effluent at 60°F.
- *I* Weight fraction of isobutane and heavier in well effluent.
- *I.G.* Volume of injected gas per barrel of tank oil.
- *Q* Volume of propane and lighter in 100 lb. of well effluent, or material.
- *q* Total gas volume of 100 lb. of injected gas.
- *r* Gas-oil ratio: cubic feet of production gas per barrel of tank oil.
- *W* Pounds of well effluent per barrel of tank oil.
- *X* Weight fraction of dark oil-gas cap portion of well effluent.
- *Y* Weight fraction of injected gas in well effluent.

Subscripts:

- 1 refers to dark-oil fluid.
- 2 refers to gas-cap fluid.
- 3 refers to injected gas.
- *m* refers to well-effluent mixture.

All gas volumes are in cubic feet at 14.73 lb. per sq. in. abs. and 60°F.

DISCUSSION

R. P. Mangold.*—Mr. Valby's paper presents an interesting method of estimating the amount of gas-cap gas and/or injected gas occurring in the effluent of a producing well. Obviously, a very considerable effort has been involved in the development of the procedure described, and the author is to be congratulated.

The basic assumptions involved are of fundamental importance in determining the applicability of the method. In particular, it would appear that assumption No. 4 (changes in reservoir pressure and temperature will not change the composition of the fluid entering the well bore) limits the use of the method to reservoirs in which the pressures are maintained above the bubble point. If pressures were allowed to decline below this point, the composition of the fluid entering the well bore would probably change continuously as the gas-oil ratio increased, on account of gas being liberated from solution, and would so greatly complicate the procedure as to make its application appear impracticable to this condition.

E. P. Valby (author's reply).—This method has been developed for pressure-control operations where the pressure is to be held above the bubble point for maximum recovery of reservoir fluids. Obviously where a pressure-control operation is used for secondary recovery, the method as presented here cannot be applied. Possibly some variation of this method can be developed to handle this problem.

* Shell Oil Co., Los Angeles, California.

An Engineering Study of the Lafitte Oil Field

By Harold Vance,* Member A.I.M.E.

(Houston Meeting, October 1944)

The Lafitte field, the largest oil reserve in South Louisiana, is in Jefferson Parish, some 25 miles due south of the City of New Orleans.

The discovery well, The Texas Company's No. 1, Louisiana Land and Exploration Co., in the southeast corner of sec. 19, T. 17 S., R. 24 E., was completed on May 15, 1935. The initial production of this well was 960 bbl. of 34.9° A.P.I. gravity oil per day, through ¼-in. choke, with a tubing pressure of 1600 lb. per sq. in. Producing depth was 9558 to 9572 ft., the total depth being 9572 feet.

The development of the field has been at the rate of three to eight new producing wells per year. Up to Jan. 1, 1944, 60 producing wells and three dry holes had been drilled, while two of the original producing wells had been abandoned.

Although the field is not unitized, The Texas Company was the sole operator in the field until the Lafitte Oil Co. completed its No. 1 Jefferson Parish, near the center of the west line of the NW/4 sec. 20, T. 17 S., R. 24 E., on July 27, 1941. No additional wells have been drilled by the Lafitte Oil Company.

Drilling and Well-completion Practices

All drilling operations have been conducted with the steam-driven rotary equipment mounted on submersible barges. A canal is dug to the well location and the drilling unit is floated into position. The seacocks are then opened and the barge settles to the bottom. After the well is completed, seacocks are closed and water is pumped out of the barge. This procedure permits the barge, with drilling equipment still in place, to be floated and moved off the location.

The conventional open-hole and the gun-perforation method of completing wells has been used in this field. Where possible, the initial completion is from the deepest sand and recompletions are made progressively up the hole, by plugging back with cement to the upper sand and gun-perforating opposite the new sand.

The oil string usually is 7⅝ in., 26 to 34-lb. casing. Three wells have been completed using 9⅝-in. 44-lb. casing set below 10,000 feet.

Fig. 1 shows the completion and recompletion practices on one well in the field. This figure also shows the relative locations of the different producing sands as shown on the electric well log.

Structure

The structure is an elongated dome, cut by two north-south faults, which divides the field into three segments. The west segment is the highest structurally and contains most of the recoverable oil and gas. The center segment is less important and the east segment is of little value.

Figs. 2, 4, 6, 8 and 10 are depth contour maps on top of the five main producing sands in the field. These maps show the relative size of the five reservoirs and the

Manuscript received at the office of the Institute Oct. 24, 1944. Issued as T.P. 1869 in Petroleum Technology, May 1945.

* Head, Petroleum Engineering Dept., Agricultural and Mechanical College of Texas, College Station, Texas.

depths to the oil-water and gas-oil contacts in each reservoir.

A salt intrusion is probably responsible for the uplift, although no salt has been encountered in any well so far drilled. One structurally low well was drilled to a depth of 12,033 feet.

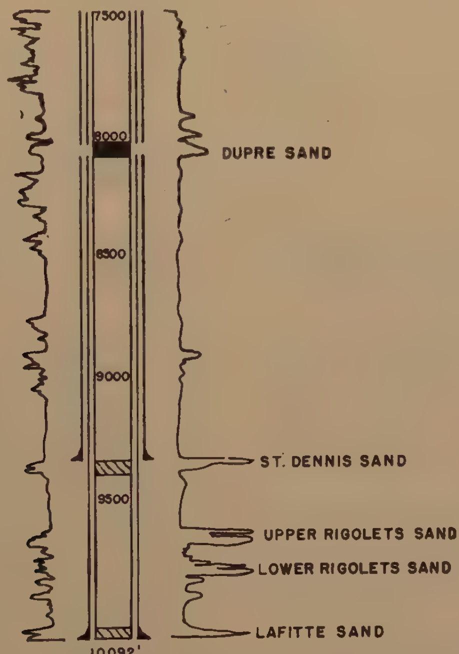

FIG. 1.—ELECTRIC WELL LOG AND COMPLETION METHODS.

The Texas Company's No. 4 L. L. and E., Lafitte, La. Completed June 26, 1936, producing from 9363 to 9420 ft. Initial production 1724 bbl. per day, ⅜-in. choke, 1480 lb. T. P., 36.8 gr. Recompleted July 24, 1937, producing from 10,060 to 10,092 ft. Initial production 1540 bbl. per day, ⅜-in. choke, 1300 T. P., 36.5 gr. Recompleted Feb. 28, 1938, producing from 8035 to 8097 ft. Initial production 1736 bbl. per day, ⅜-in. choke, 875 lb. T. P., 33.0 gr.

Casing record: 7⅝ in., 26.75 lb. at 9363 ft. cemented with 1000 sacks; 5¾ in., 22.5 lb. at 10,092 ft. cemented with 100 sacks.

PRODUCING SANDS, WELL SPACING

Lafitte is a typical multiple-sand field. The west segment contains the largest number of productive sands. Table 1 contains pertinent data on the different producing sands in the field, and the well spacing in acres per well in the west segment of the field.

The Dupre sand, St. Dennis sand, Upper and Lower Rigolets sands, and the Lafitte sand reservoirs in the west segment have been developed sufficiently to make a reservoir study.

All the producing sands in the field are believed to be of middle Miocene age.

CORE ANALYSIS

Fig. 12 is a graphical representation of the core analysis of the upper part of the Lower Rigolets sand in one well. It is believed that analysis made on the other producing sands would reveal high porosities and variable permeabilities.

PRODUCTIVE AREA

The maximum productive area of the field—that is, the area in which some sand

TABLE 1.—*Data on Lafitte Field*

Producing Sand	Depths, Ft.	Average Thickness, Ft.	Number of Wells That Have Produced from This Sand up to Jan. 1, 1944 (Entire Field)	Well Spacing, Acres per Well, West Segment Only
Dupre	8,045–8,076	28	4	80
St. Dennis	9,300–9,795	28	22	90
Upper Rigolets	9,955–10,090	52	16	49
Lower Rigolets	9,790–10,100	50	18	65
Lafitte	9,990–10,070	36	5	62
Stray	4,390–10,066		8	

will produce either oil or gas—is approximately 2000 acres.

The breaking up of the subsurface structure by faulting has produced a number of isolated productive areas in the field. In these isolated areas there are several productive sands, which are not interconnected one with the other. Thus, there are a number of different oil and gas reservoirs that must be developed and produced as though they were separate and distinct oil fields.

Table 2 shows the oil and gas productive area in the west segment of the field for the five main producing sands.

TABLE 2.—*Productive Area, West Segment of Field*

Sand	Total Oil Productive Area, Acres[a]	Total Free Gas Productive Area, Acres
Dupre	321	no gas cap
St. Dennis	1,077	270
Upper Rigolets	587	1,030
Lower Rigolets	780	330
Lafitte	310	no gas cap
	3,075	1,630

[a] Total area under which oil may be encountered in the sand, even through free gas in the top of the sand and water in the base of the sand.

OIL AND GAS PRODUCTION

The total oil production through 1943 was 35,662,264 bbl. The total gas production through the same period was 39,285,054,000 cu. feet.

Table 3 shows the oil and gas production from the field by years.

TABLE 3.—*Oil and Gas Production*

Year	Oil Production, Bbl.	Gas Production, Millions Cu. Ft.	Over-all Producing Gas-oil Ratio
1935	631,263	395,990[a]	627
1936	2,708,509	2,058,247[a]	760
1937	4,136,174	4,876,595	1,180
1938	5,861,846	6,634,489	1,130
1939	4,745,085	5,704,954	1,200
1940	4,602,352	5,844,034	1,270
1941	4,538,590	5,718,485	1,260
1942	3,749,854	3,996,593	1,070
1943	4,688,591	4,055,667	865
Total	35,662,264	39,285,054	Ave. 1,100

[a] Estimated, also first half of 1937 gas production estimated.

TYPE OF CRUDE

The A.P.I. gravity of the crude varies from 33.9 to 39. Table 4 shows analysis of crude produced from the St. Dennis sand.

TABLE 4.—*Analysis of Crude Produced from St. Dennis Sand*

Gravity, deg. A.P.I. at 60°F. 36.9
Sulphur, per cent by wt. 0.16
Initial boiling point. . . . . 176.0°F.
Paraffin base

Yields

Product	Per Cent	Gravity, Deg. A.P.I.
Gasoline	15	55.4
Naphtha	5	47.9
Kerosine	25	42.5
Distillate	10	37.6
Gas oil	20	33.3
Wax distillate	20	27.6
Residue	5	
	100	

Octane number of gasoline. 45

RATE OF OIL PRODUCTION

During the early life of the field, individual well productions exceeded 1000 bbl.

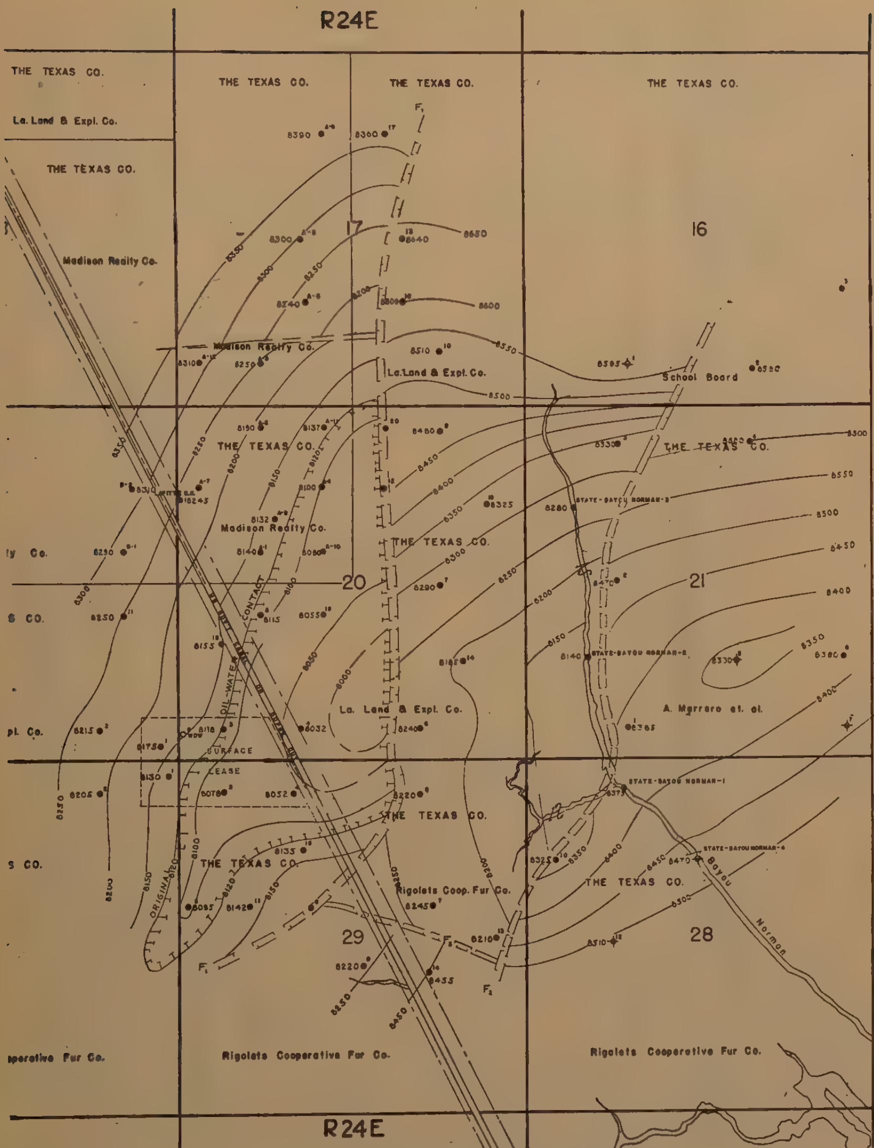

FIG. 2.—CONTOUR MAP ON DUPRE SAND.

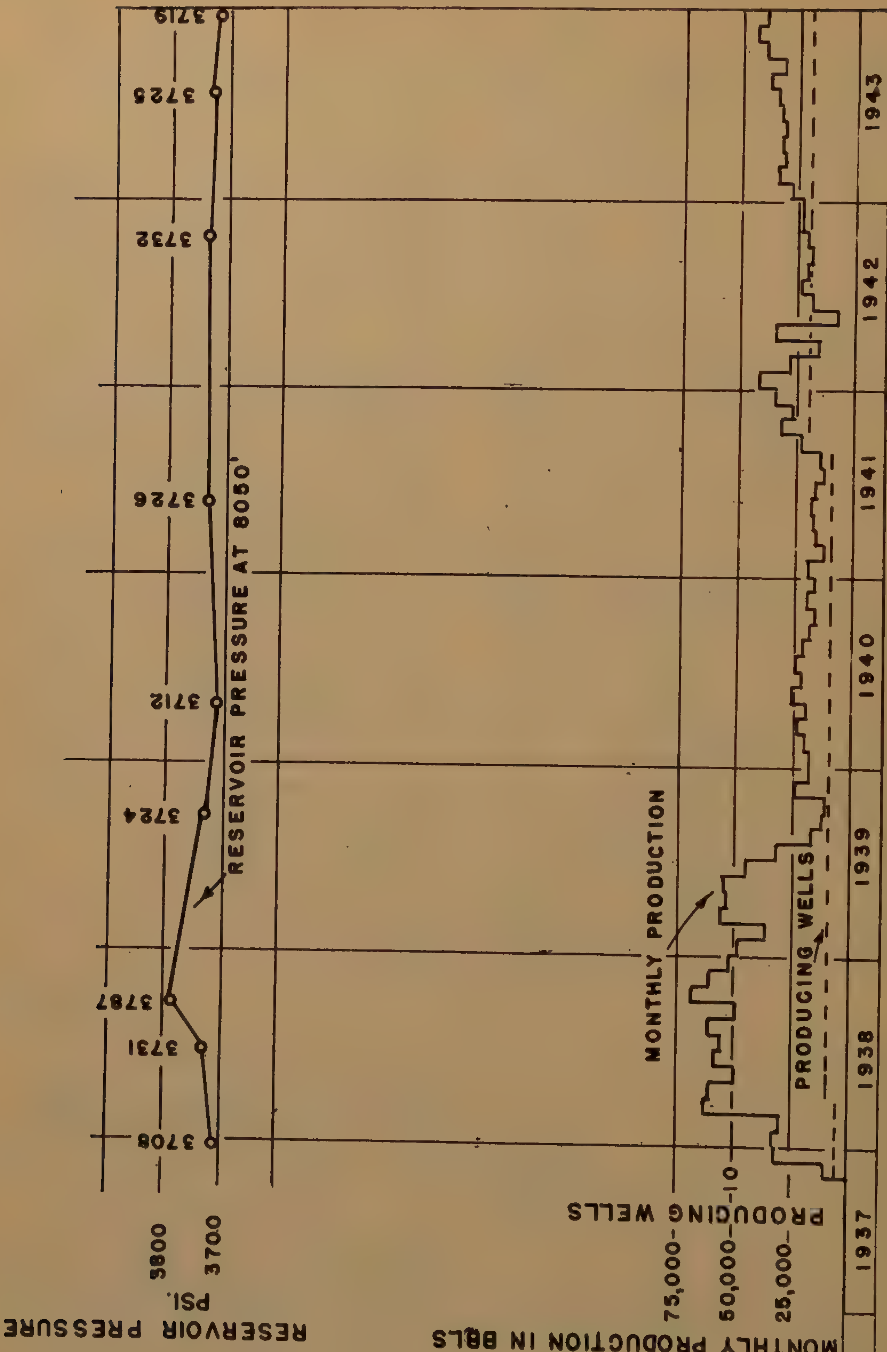

FIG. 3.—RESERVOIR PERFORMANCE, DUPRE SAND.

Fig. 4.—Contour map on St. Dennis sand.

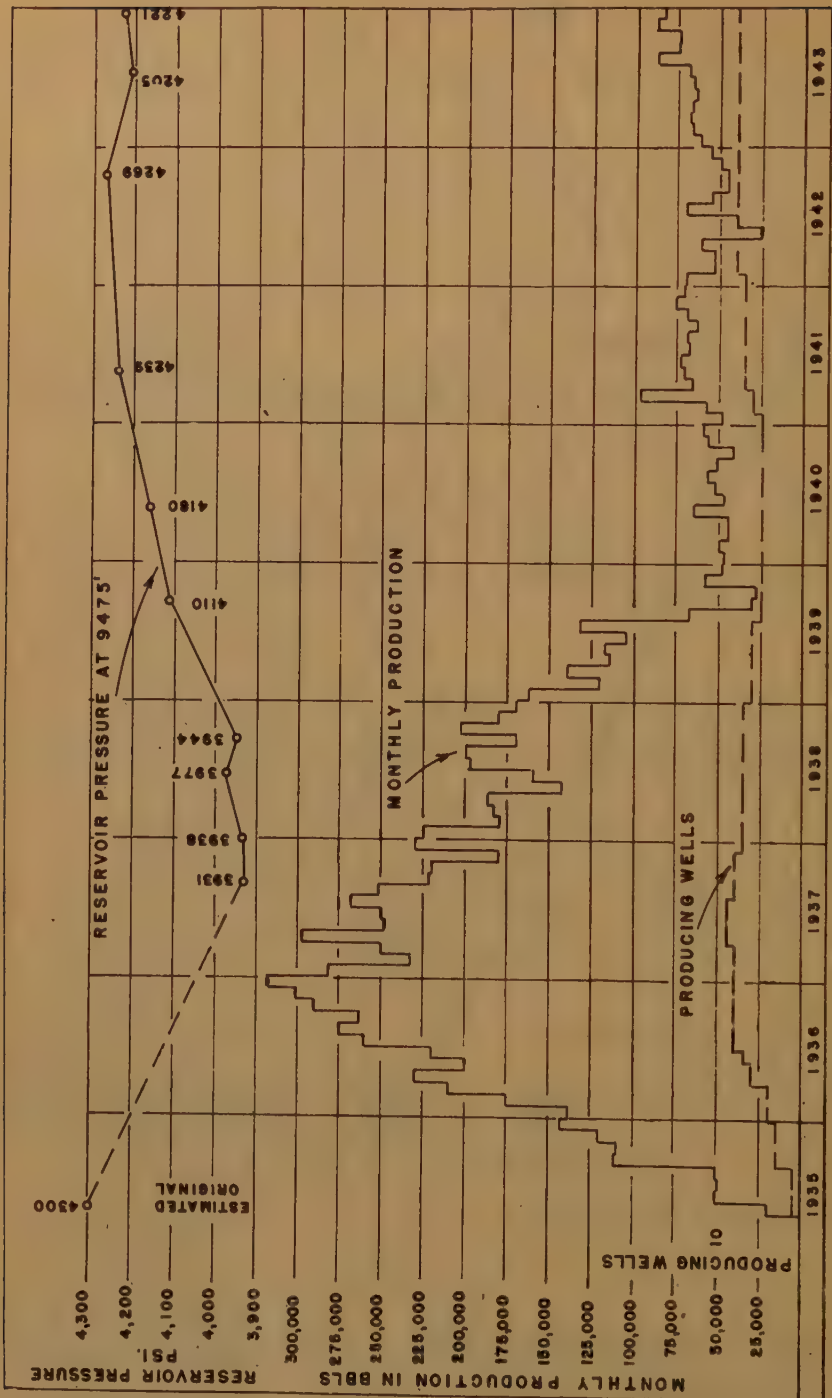

FIG. 5.—RESERVOIR PERFORMANCE, ST. DENNIS SAND.

Fig. 6.—Contour map on Upper Rigolets sand.

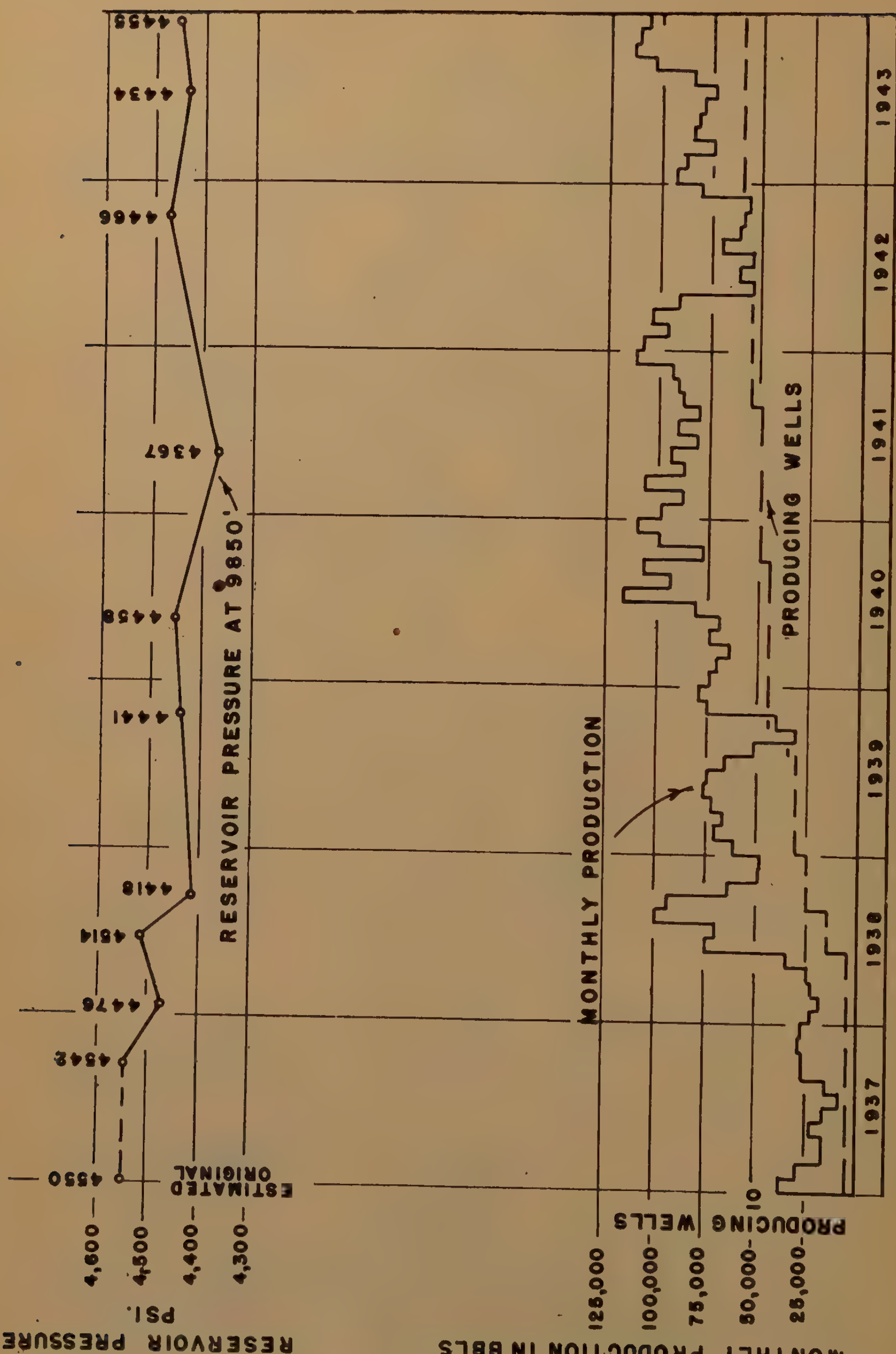

Fig. 7.—Reservoir performance, Upper Rigolets sand.

FIG. 8.—CONTOUR MAP ON LOWER RIGOLETS SAND.

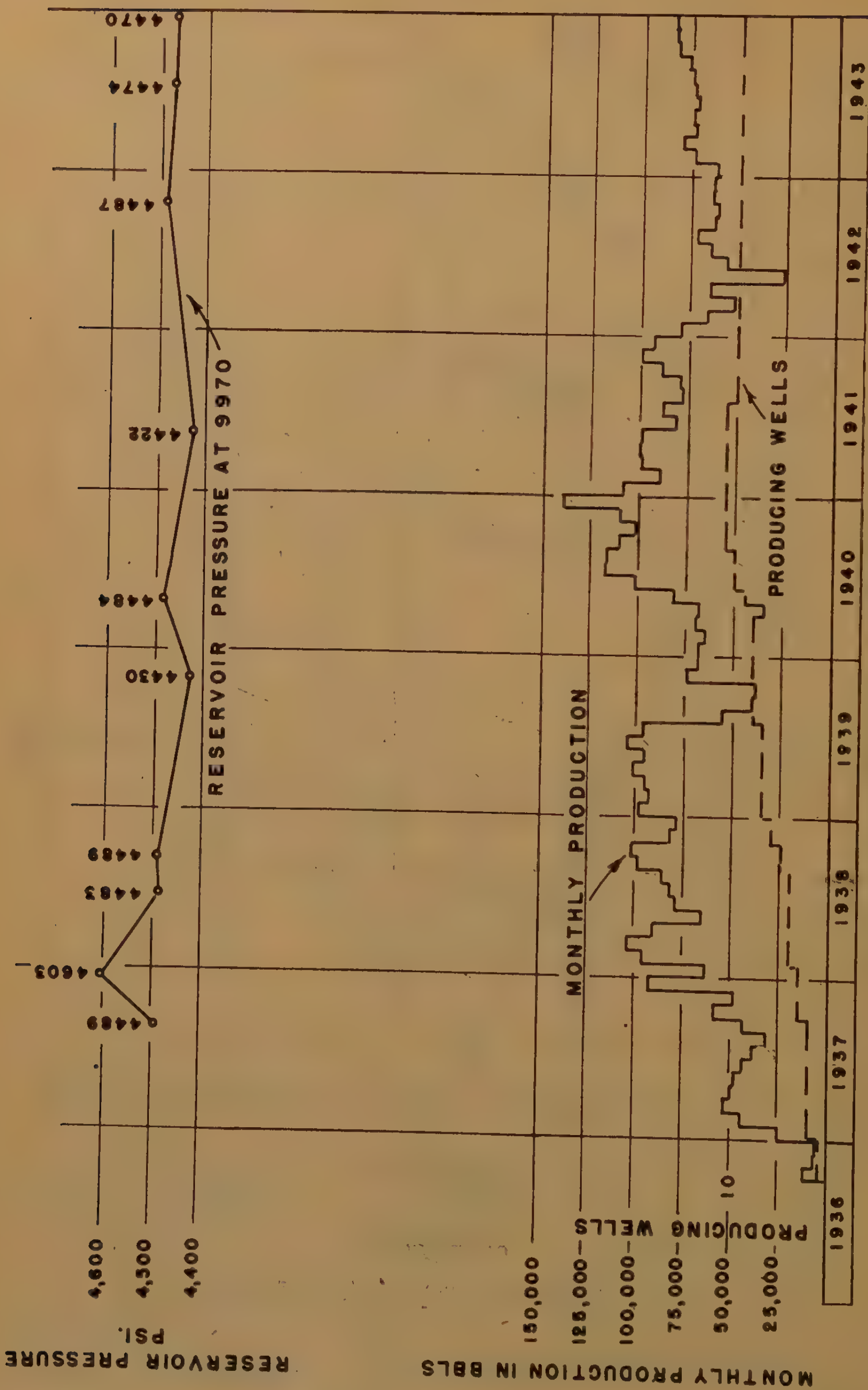

FIG. 9.—RESERVOIR PERFORMANCE, LOWER RIGOLETS SAND.

FIG. 10.—CONTOUR MAP ON LAFITTE SAND.

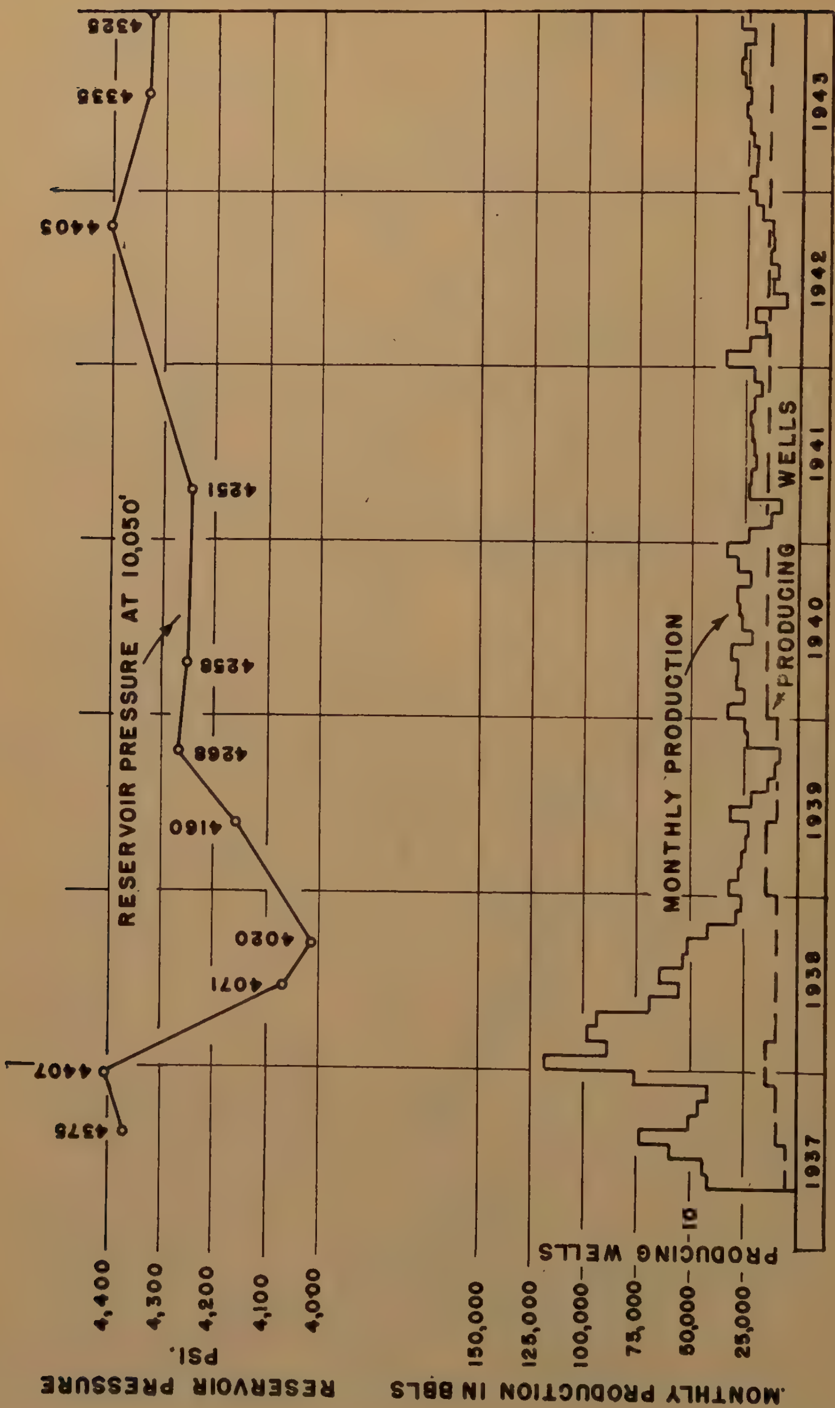

FIG. 11.—RESERVOIR PERFORMANCE, LAFITTE SAND

per day. As more wells were completed, the individual well productions dropped. In the years 1937 and 1938, the average well productions were in excess of 600 bbl. per day, but for the last few years the average daily productions have ranged between 250 and 300 barrels.

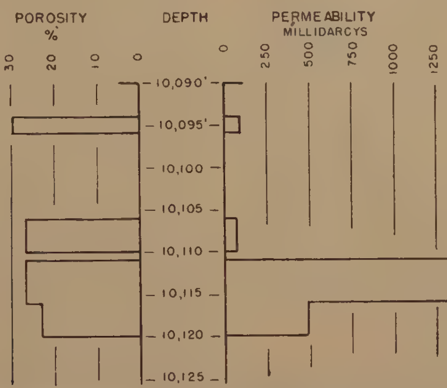

FIG. 12.—GRAPHICAL REPRESENTATION OF CORE ANALYSIS OF UPPER PART OF LOWER RIGOLETO SAND IN ONE WELL.

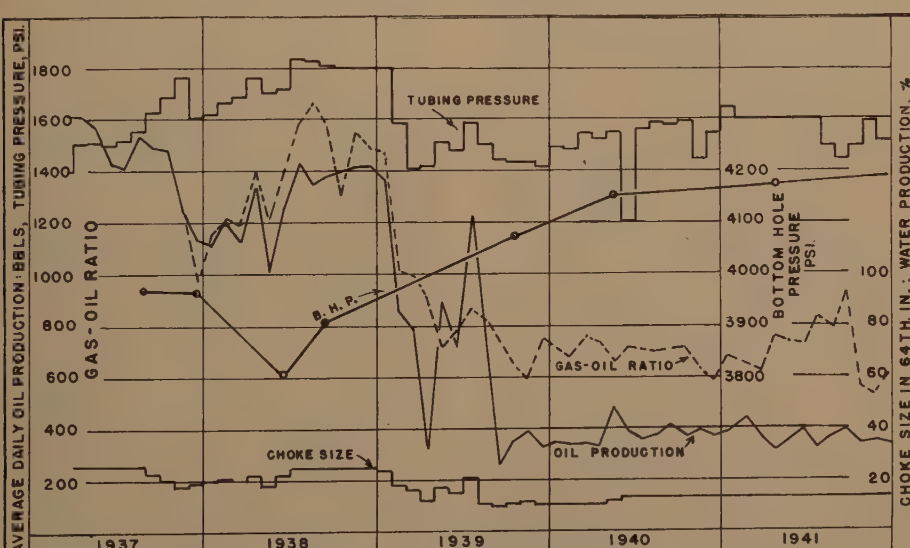

FIG. 13.—WELL-PERFORMANCE CURVE.

Fig. 13 shows the effect of high rates of production on The Texas Company's No. 6 Rigolets, which produces from the St. Dennis sand at a point 67 ft. below the known gas-oil contact. The performance of this well is not typical of all wells in the field, or even of those producing from the same sand, but it does show the importance of individual well studies.

The writer prepared individual well-performance curves like the one shown in Fig. 13 and found them useful in helping to tie in faults that were not clearly revealed from the electric well logs in widely spaced wells.

Reservoir Performance

Figs. 3, 5, 7, 9 and 11 are reservoir-performance curves for the five main producing sands in the west segment of the field. The pressure in all of these reservoirs is being maintained by the natural encroachment of water. The early history of the Lafitte sand reservoir indicated this reservoir to be under gas drive, but a decrease in withdrawals shows that the reservoir has an active water drive under restricted production.

These charts indicate approximate monthly production that should maintain the pressure in each reservoir.

Three of these reservoirs contain a gas cap above the oil. The pressure in the gas cap may be maintained near the original pressure while the oil is being produced. Additional wells properly located may be necessary to drain the oil completely from beneath the gas caps.

Summary and Conclusions

The Lafitte field is a typical deep-seated dome in which no salt has yet been encountered.

Three of the five main producing sands have a gas cap. All the sands in the west segment of the field are under an active water drive, which in some places is almost 100 per cent effective.

Early productive history of a reservoir may sometimes lead to the wrong conclusions, as illustrated herein in the case of the Lafitte sand. The early rates of withdrawal of 100,000 bbl. of oil per month from this sand brought about a pressure-decline curve similar to those expected for a gas-drive reservoir. The reservoir-performance curve for this sand indicates a maximum withdrawal of 22,000 to 25,000 bbl. per month if the reservoir pressure is to be maintained.

Reference to the reservoir-performance curves for the other producing sands will indicate the maximum withdrawals possible to maintain reservoir pressure.

Acknowledgments

The writer wishes to thank the Louisiana Land and Exploration Co. and the Rigolets Corporation for the opportunity to make this study, and for permission to publish this paper.

The writer also wishes to thank The Texas Company, which was the source of the original data on the field.

An Introductory Discussion of the Reservoir Performance of Limestone Formations

By A. C. Bulnes* and R. U. Fitting, Jr.,† Junior Member A.I.M.E.

(Houston Meeting, May 1944)

Abstract

Field experience with limestone and sandstone production indicates the existence of wide differences between the reservoir behavior of these two types of formation. Little attention appears to have been given to the separate study of the flow of fluids and the retention of fluids in limestones. This paper presents data and arguments to demonstrate the existence of a difference between the two types of formation, and urges the separate intensive investigation of limestone reservoirs. All experimental data presented pertain to dolomitic limestone formations in West Texas and New Mexico.

Two kinds of porous media are recognized—intergranular and intermediate. Intergranular rocks are those in which the porosity and permeability are determined by the geometrical properties and the sorting of the sedimentary units; intermediate rocks, those in which there is no direct relationship between grain properties and the porosity and permeability. Limestones in general are intermediate media. The partial relationship between porosity and permeability of any class of porous media is represented by an area of finite extent and definite shape on the permeability-porosity plane.

The horizontal and vertical variations of porosity and of permeability in limestone and sandstone formations are discussed and compared.

Comparisons are made of connate-water content, the relative permeability-saturation relationship, and capillary phenomena in the two kinds of rocks.

A number of tentative conclusions are drawn relative to the reservoir properties of limestones; in particular, (1) dolomitic limestones are oil bearing and apparently are oil productive in zones of permeability less than 0.1 millidarcy, and (2) primary depletion (by gas expansion) oil saturations may be lower in dolomitic limestones than in sandstones.

Introduction

It is well known that the reservoir performance of limestones displays numerous irregularities when compared with that of sandstones, and that the departures from "normal" behavior of limestones are more frequent and generally more marked than in sandstones. This is particularly true of fractured limestones and those that have undergone considerable development of secondary porosity.

A review of the literature of production research published during the past 15 years reveals a startling absence of theoretical and experimental investigations directed specifically toward explaining and predicting the performance of limestone reservoirs, even though such problems as the prediction of water encroachment and the estimation of ultimate recoveries continue at the "inspired guess" stage. By far the greater part of the experimental data reported pertain to measurements on sandstone core samples, while the theoretical studies, almost without exception, are developed from the assumption of an ideal porous medium and therefore seldom are applicable to limestone formations. The chief cause of this situation appears to be the common belief that, to all practical intents and purposes, sandstones and the majority of producing limestone formations

Manuscript received at the office of the Institute Sept. 25, 1944. Issued as T.P. 1791 in Petroleum Technology, January 1945.

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belong to the same category of porous media.

The importance of the separate study of limestone reservoirs from the geological viewpoint has been recognized for many years,[1] and it is our conviction that they are equally deserving of separate study from the physical viewpoint. Since the cause of neglect from this stand appears to be the tacit assumption that sandstones and limestones do not differ materially in reservoir performance, we believe that as a first step toward a correct understanding of limestones it is necessary to show that such a difference does in fact exist. It is the purpose of this paper to attempt to establish this difference upon the basis of inferences that may be drawn from the obvious difference in the nature of the internal void systems of sandstones and cavernous and/or fractured limestones; and upon the basis of laboratory and field data derived from producing limestone formations in West Texas and New Mexico. In addition, certain *tentative* conclusions have been arrived at regarding limestone reservoir performance, which are included herein, not so much in the belief that they are correct as in the hope that they may stimulate salutary controversy, which will result ultimately in their being established definitely as right or wrong.

Comparison of Void Systems of Sandstones and Limestones

Apart from their differences of chemical or mineralogical composition, the chief difference between limestones* and sandstones is the difference in the origin and geometry of the internal-void systems of the two kinds of rock. There is a fundamental difference between the geometry of the pore space of a sediment that has undergone only deposition, compaction and cementation and one that has undergone, in addition, dissolution and fracturing. In general, limestones belong to the latter class.

In sandstones the total internal-void volume is characterized by a high degree of dispersion and by a high degree of interconnection between its elements. Moreover, the small openings that in the aggregate constitute the total void volume are of the same or a smaller order of size than the sand grains themselves, providing that bridging is everywhere absent, and their geometry is determined by the geometry of the sand grains. These features are particularly evident in the void system of unconsolidated sands, and they are not necessarily modified by subsequent compaction, or by deposition in the intergranular spaces of finely divided solid particles and/or cementing material precipitated from solution, since the latter processes follow the intergranular distribution pattern of the original, unconsolidated pore system, while the former process does not alter it.

If a limestone has nowhere suffered fracture or any evolutionary process by which its internal-void volume has been increased at the expense of the original sedimentary units, there is no reason to expect any fundamental difference between its void system and that of a sandstone. For if it is free of secondary openings—whether the limestone is of clastic, organic or chemical origin and whether the fundamental sedimentary units from which it is built up are calcitic fragments, or shells, or crystals precipitated from solution—the geometry of its internal-void space is determined by the number and the geometrical properties of the elementary units themselves; hence it possesses a void system of the same type as that of a sandstone.

Fissures, solution caverns and other similar induced openings constitute voids whose shapes and sizes are independent of the geometrical properties of the sedimentary units, whose volumes may be

[1] References are at the end of the paper.

* We exclude the oölitic limestones from this discussion.

enormously greater than that of these units, and, finally, whose presence in the solid void matrix destroys the previous uniform pattern of "intergranular" void dispersion. Thus the void system of a fractured or cavernous limestone does not fulfill the conditions characteristic of that of a sandstone.

These considerations lead us to recognize two distinct types of sedimentary rocks distinguished solely according to the geometry of their internal-void systems. In the first type of rock the size and shape and the spatial distribution of the pores, and the way they are interconnected, are determined essentially by the number, the geometrical properties and the distribution of the sedimentary units. In the second type, in addition to the intergranular openings, cavities occur, whose size, shape and position in the rock bear no direct relationship to the number, to the geometrical properties or to the spatial distribution of the sedimentary units. These two classes of rocks represent two distinct classes of porous media, which we may term, respectively, intergranular and intermediate.* In general, sandstones represent intergranular media, whereas most limestones belong to the class of intermediate media.

Relationship between Porosity and Permeability in Sandstones and Limestones

The porosity and permeability of a sedimentary rock are determined by the geometry of the void system, and this in turn, whether the rock is intergranular or intermediate, is determined by the geometrical properties of the sedimentary units and by the type and duration of the several evolutionary processes that have been undergone by the sediment. Sandstones undergo processes that cause the porosity and permeability to vary, but the sandstones remain essentially intergranular porous media. Limestones undergo similar processes, but, because of their solubility in water and their ability to hold a fracture, they also respond markedly to other processes, which not only change the porosity and permeability, but, by enlarging intergranular channels or by creating entirely new openings, transform the void system from the intergranular into the intermediate type. When this occurs the fruitful analogy between the flow of fluids in a porous medium and the flow of electricity in a uniform conductor breaks down. It is no longer possible to infer accurately the properties of the whole medium from those of a volume element, for in an intermediate medium the permeability and the porosity of the element depend upon its shape, size and the point of origin, and (as regards the permeability) upon its orientation during test.

Table 1.—*Comparison of the Porosity and Permeability of a Consolidated Sandstone and a Cavernous Limestone*

Sandstone		Limestone	
Permeability, Millidarcys[a]	Porosity, Per Cent	Permeability, Millidarcys[a]	Porosity, Per Cent
2,650 H	26.1	150	27.5
6,300 H	29.6	1,850	6.5
2,400 H	25.8	1,520,000	26.0[b]
450 V	23.4	<0.1	7.0
1,100 V	25.7	<0.1	5.5
620 H	26.1	2,670,000	36.5[b]
Average 2,250	26.1	699,000	18.2

[a] H = permeability measured parallel to the bedding plane.
V = permeability measured perpendicular to the bedding plane.
[b] Volume of cavernous conduit was included in the total void volume.

Consequently the terms "specific porosity" and "specific permeability" are meaningless when applied to such media.

* A third class of media, which the authors term foramenular, consists of openings in and/or through an otherwise massive, continuous solid; e.g., a mass of glass containing bubbles; a pipe. The intermediate media constitute a class between the intergranular and the foramenular, partaking of the qualities of each.

It is true that sandstones never possess the homogeneity possible in electrical conductors, nevertheless their departure from uniformity is of a considerably lower degree than may occur in intermediate limestones. This is illustrated by comparison (Table 1) of the porosities and permeabilities of two groups of conventional test plugs (cylinders 1 in. long by ¾ in. in diameter). One group was cut at random from a core of uniform Gulf Coast sandstone, and the other from a fragment of cavernous limestone of about the same bulk volume.

Evidently the sandstone is not homogeneous; nevertheless, it is not unreasonable to suppose that any other set of plugs into which the core might have been cut arbitrarily would have yielded permeabilities and porosities whose averages would have been, respectively, in the neighborhood of 2000 millidarcys and of 26 per cent, irrespective of the number, shape and size of the plugs* and their orientation with respect to the bedding plane. Under such conditions, it is not unreasonable to say that the specific permeability of the sand core was, say, 2500 millidarcys and the specific porosity 26 per cent. However, for the limestone, it would have been possible to arrive at almost any average permeability between 1 and 1,000,000 md. and any porosity between, say, 7 per cent and 20 to 25 per cent, by varying the number, shape and size and orientation (during permeability test), of the plugs. For example, the permeability of the two highly permeable plugs of Table 1 would have been of the order of less than one millidarcy in a direction at right angles to the one in which they were actually measured, and on this basis the average permeability would have been in the neighborhood of 300 md. Again, by cutting the plugs so as to have excluded cavernous openings. the results would have reflected the properties of the intergranular matrix; namely, a porosity of about 5 per cent and a permeability of less than 0.1 md. It is apparent that the use of core analyses only to determine the porosity and permeability of a limestone reservoir of this type can scarcely lead to correct results even where core recovery has been 100 per cent. (Actually the most permeable sections are rarely recovered in limestones of highly intermediate* porous structure.) Consequently, it is not too much to say that the porosity and permeability of such a reservoir can best be determined in terms of its over-all shape and size and flow performance.

Evidently the partial relationship between porosity and permeability in test plugs of intermediate limestones is different from that in sandstones. For example, whereas a sandstone of 26 per cent porosity might have a permeability as low as less than 0.1 md., it is doubtful whether the permeability could exceed 10,000 millidarcys if nonintergranular voids were everywhere absent; however, it has already been shown that an intermediate limestone of this porosity may exceed 1,000,000 md. permeability, while, had the cavernous opening in this case been vesicular instead of penetrating, the permeability might well have been less than 0.1 md. However, a large number of producing limestone formations give little indication of containing highly cavernous or fissured zones although the effects of both dissolution and fracture are probably present. The question then arises: Can simple laboratory tests on cores from such formations reveal whether or not they are of intermediate character?

Fraser,[8] in discussing the porosity and permeability of intergranular porous media, says:

> The following factors . . . control the porosity of unconsolidated natural deposits: (1)

* Providing, of course, that the plugs were always large in relation to the grain size.

* One in which nonintergranular voids constitute the greater part of the total void volume.

> absolute grain size; (2) nonuniformity of grain size; (3) proportions of various grain sizes; (4) shape of grains. In addition porosity is affected by the following more general factors: (5) method of deposition; (6) compaction during and following deposition; (7) solidification.

while, according to the same author, the coefficient of permeability is determined by

> uniformity and range of grain size; shape of grains, nature and uniformity of packing; surface condition of the grains, stratification, consolidation and cementation of the material.

Comparison of these statements shows that the only factors determining permeability that are not included among those determining the porosity are surface condition of the grains and stratification. However, if in a given sandstone core sample it were possible to hold constant all the factors listed as determining porosity, while varying stratification, it is reasonable to expect that the porosity would show some corresponding variation, albeit of small magnitude. The same applies to the variation of the surface condition of the grains, other factors being kept constant.

Suppose we assume, therefore, that the porosity and permeability of intergranular media are determined by the same variables (that is, quantitative representations of the factors listed in the preceding paragraph), and that continuous mathematical functions exist between the porosity and the permeability and these factors. If these assumptions are valid, then, since neither the porosity nor permeability is ever infinite, all possible values of the porosity and permeability of intergranular media should lie in an area of definite shape and size on the porosity-permeability plane, an area that should be approximately outlined by the plot of a large number of porosity and permeability measurements on cores of intergranular void structure.

We have attempted to determine the "intergranular area" of sediments composed of units whose sizes are in the range of those customarily found in sands and sandstones. Our results are shown in Fig. 1, in which are plotted the porosity and permeability measurements of about 2200 consolidated and unconsolidated sand samples. One-tenth millidarcy was chosen as the lower limit for permeability because lower values are not usually determined in routine test. Points on the perpendicular through 0.1 md., however, may be equal to or less than this value, and are included merely to confirm the contention that very small permeabilities may be associated with a wide range of porosity values. The choice of 100,000 md. as an upper limit to the permeability scale provided for as much upward variation as the bulk of our data and the nature of sandstone permeability required, but is not meant to imply that intergranular porous rocks may not have very much higher permeabilities.

About 1300 of the samples were obtained from sandstone pays of four fields in southeast Texas, three fields in east Texas and three fields in southern Louisiana, about the same number of samples coming from each of these fields. Also included are many of the data of Fancher, Lewis and Barnes;[3] all of the data of Hill and Guthrie[4] pertaining to sandstone samples from the Rodessa field of Louisiana, Texas and Arkansas, and some of the data of Carpenter and Schroeder[5] from the Anahuac field, Chambers County, Texas, to illustrate the association of high porosity with relatively low permeability. A few data on high permeabilities were taken from Muskat (p. 113 of ref. 6) and from Krumbein and Monk,[7] and the data on a few samples of sandstone from California and from scattered producing sandstone formations in the Mid-Continent have been included.

Whenever available, the total rather than the effective porosity has been used, since the total porosity, being less dependent on the method of measurement, is

more strictly a lithologic factor than the effective porosity. (By the same token, it would have been preferable to use values of permeability calculated from lithologic rather than fluid-dynamic data. However, this was plainly impracticable except in a few cases,[7] hence only the latter type of data have been used.) Comparison reveals, however, that for uniform sandstones the two porosities are practically equal, and on this basis we have felt justified in including the data of Fancher, Lewis and Barnes,[8] although, as will be brought out later, it appears probable that the effective porosity of a few of their samples was several units lower than the total porosity.

The majority of the permeability measurements were made with air as fluid, and, as far as we are aware, the mean air pressure in the samples was moderate during the tests. Although the air data below about 10 millidarcys may be considerably in error according to Klinkenberg's[8] work, enough liquid data were available to indicate, with sufficient accuracy for our purposes, the outline of the intergranular area in this region, and it was found that the uncorrected air data conformed to it satisfactorily.

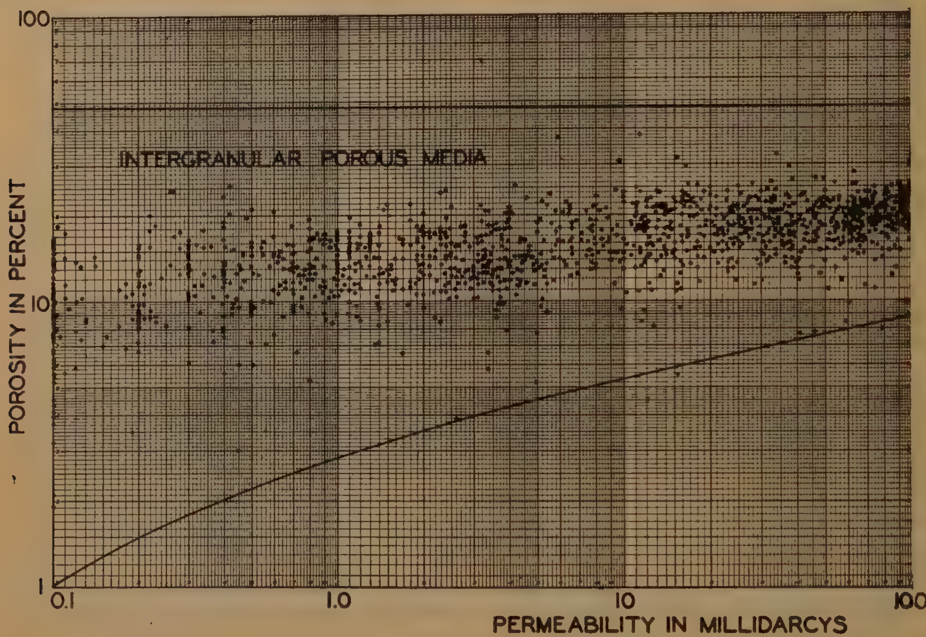
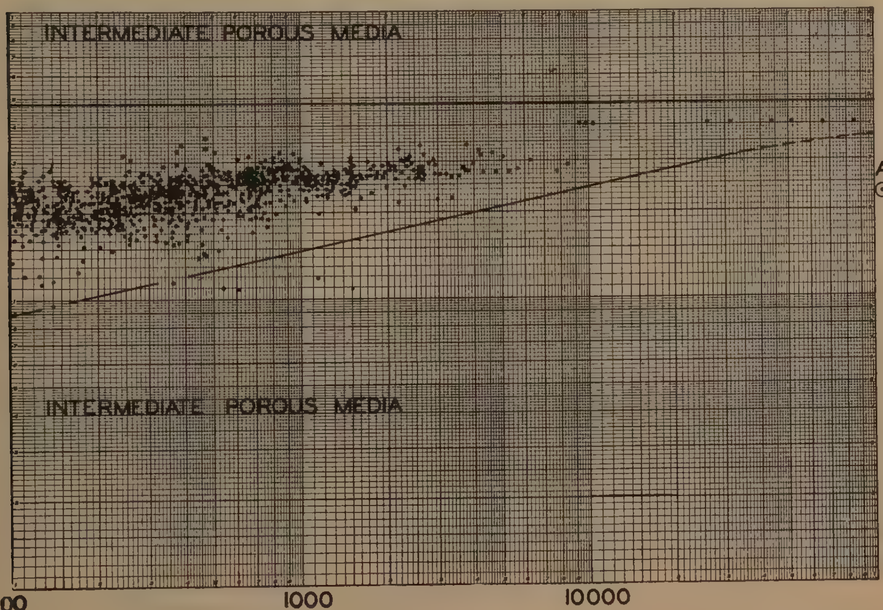


FIG. 1.—POROSITIES AND PERMEABILITIES OF

It is clear that insufficient points are accumulated in Fig. 1 to outline definitely the intergranular area. The data are not so much lacking in number as in variety; that is, variety as regards the manner of evolution of the samples. For example, the reason for the thinning out of points in the region below 10 per cent porosity and to the left of the 10-md. ordinate probably is that points falling in that region represent conditions of intergranular void geometry that are comparatively rare in sandstones of natural origin; hence only a few would be present in a numerous assemblage of random data. Therefore, what has been obtained is the part of the general intergranular area that pertains to a certain class of intergranular porous media of natural origin; viz., the sandstones.

An attempt has been made to locate approximately the lower boundary of the general intergranular area for media composed of elementary units whose size range does not exceed that of the grains composing consolidated and unconsolidated sands. This was done by drawing the solid line through the loci of three points corresponding to samples containing fine cracks produced by laboratory handling, and, as it were, on the dividing line between intergranular and intermediate porous media; and a number of the data of Fancher, Lewis and Barnes[3] on Bradford, Wilcox, Johnson, 3rd Venango and Glade sandstones. It is possible that the deviations of the latter samples are caused by some inhomogeneity, especially in the 3rd Venango samples, since this sand is notoriously irregular; or they may reflect the difference between the effective and the absolute porosity of the samples, since, as already mentioned, the majority of our data represent absolute porosities while those of Fancher, Lewis and Barnes are effective porosities.* In all of these cases the addition of a few units of porosity would serve to place these points in accord with the remainder of the plot.



ABOUT 2200 SAND AND SANDSTONE SPECIMENS.

The upper boundary was taken to be the horizontal line, porosity equals 47.64 per cent—i.e., the maximum porosity of an ideal intergranular porous medium—on the assumption that by varying the size of

* To illustrate the magnitude of the differences that may exist between the porosity values derived by the two methods, we have selected and show below several data on two of these sands, from Table 5, page 119, of the paper cited.[3]

Sample No.	Sand	Field	Total Porosity, Per Cent	Effective Porosity, Per Cent
11	3rd Venango	Oil City	7.5	4.8
25	3rd Venango	Pleasantville	17.1	14.7
37	Bradford	Kane	13.0	10.2
40	Bradford	Kane	16.4	14.4
41	Bradford	Kane	17.4	13.6

the uniform spheres any permeability between 0.1 md. and several hundred thousand millidarcys could be obtained, and we anticipate the existence of an extensive intermediate region above the intergranular area, since porosities in excess of 47.64 per cent require the presence of cavities due to bridging among the grains or other nonintergranular openings.

Although a point falling within this area may correspond to either an intergranular or an intermediate porous medium, *all* points falling *outside* the area correspond to intermediate porous media. With this criterion in mind, the porosity and permeability of about 1200 dolomitic limestone samples have been plotted in Fig. 2.

These data were obtained from the pay zones of the following fields in West Texas and New Mexico: Wasson, Slaughter, Seminole, Yates, Foster, Jordan, Goldsmith, Ownby, Monahans (Ellenburger), Russell, Means, Hobbs, Eunice and Vacuum. In addition, the data of Fancher, Lewis and Barnes[3] on two samples of Onondaga dolomitic limestone have been included.

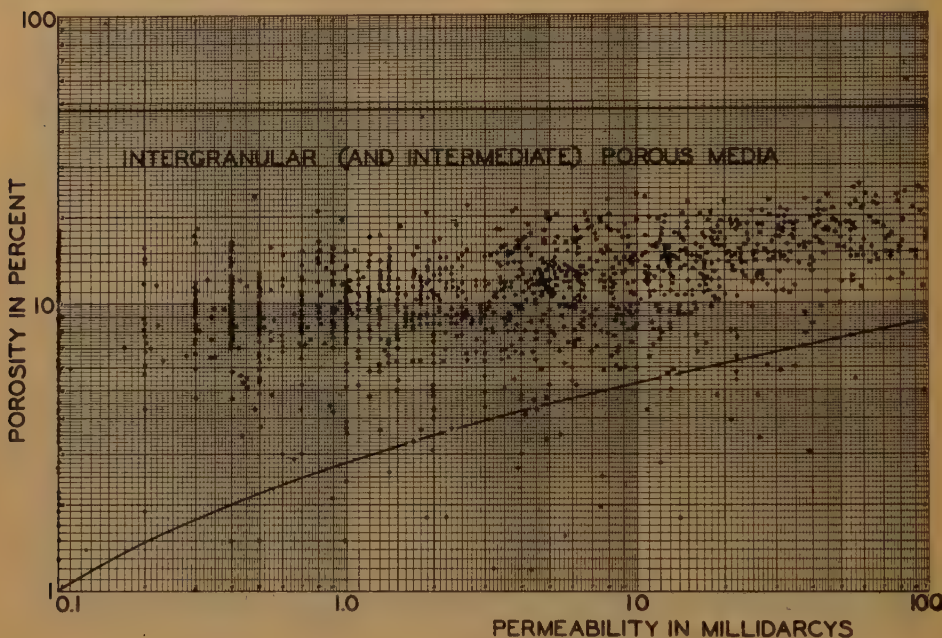


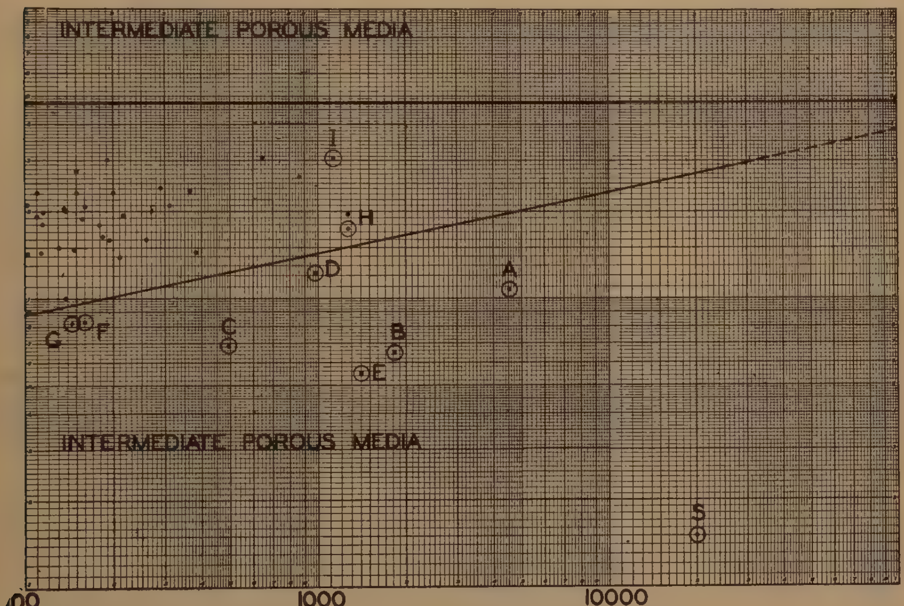
Fig. 2.—Porosities and permeabilities of

About half the number of points represent samples from the San Andres dolomite at Wasson, while the remainder are divided nearly equally among the other fields listed above.

The permeabilities of all but 10 of these samples were measured with air. As far as we are aware, only three effective porosities are shown, the remainder being total porosities.

The majority of these samples were of smooth texture, and, based on their appearance, could have been with safety pronounced intergranular. Very few showed openings as large as 1 mm. in diameter, and, in general, the ones that did were not particularly permeable, owing to the vesicular rather than piercing character of these cavities. However, the relatively high percentage of points below 10 per cent porosity but above the boundary line in Fig. 2

compared with Fig. 1 indicates that some evolutionary process of comparatively common occurrence in limestones is relatively rare in sandstones. It seems reasonable to suppose this process to be dissolution, or fracturing, and the region in the neighborhood of the boundary represents the locus of incipient development of secondary openings due to these and perhaps other processes.



ABOUT 1200 DOLOMITIC LIMESTONE SPECIMENS.

Fig. 2 appears to show also that high permeabilities are rare in limestones of intergranular or moderately cavernous character. This is indicated by the marked thinning of points above 300 or 400 md. Furthermore, since these samples were in general crystalline in texture, the data, apart from those that definitely indicate the intermediate condition, may be representative of the class of well consolidated, *crystalline* intergranular porous media.

The degree of scattering of the sets (representing different fields) of limestone data, was nearly equal, so that the outline of the area did not change appreciably after the first set of data had been plotted. The scattering of the sets of sandstone data was much less, and many of them fell into roughly linear correlations. Every set of limestone data contained a few points that fell in the intermediate area, and we infer from this that probably all producing limestone formations have undergone localized development of nonintergranular openings.

The point in Fig. 1 marked *A* and the points in Fig. 2 marked *A* and *B* show the effect upon permeability of a comparatively modest increase in porosity due to dissolution. Point *A*, Fig. 1, represents a sandstone core that had been treated with a solution of hydrofluoric acid, whereby a narrow streak of argillaceous material running lengthwise through the core was removed. Prior to the acid treatment, the porosity was 16.1 per cent and the permeability was 0.55 md. After acid treatment, the porosity (including the solution

cavern) was 23 per cent and the permeability was 108,000 millidarcys.

Points *A* and *B*, Fig. 2, show the effect of acid treatment on limestone. The data

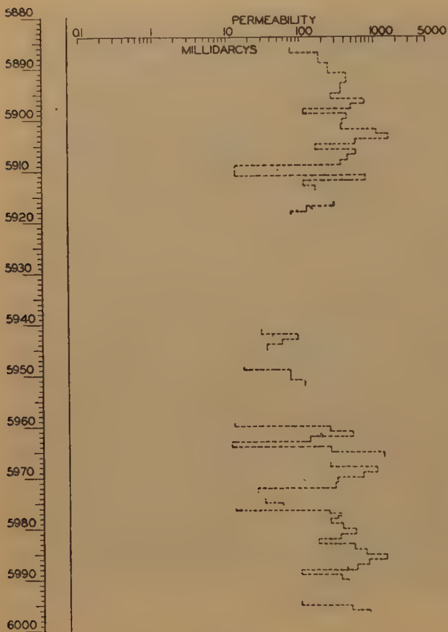


FIG. 3.—PERMEABILITY PROFILE, SAND WELL A, SOUTH TEXAS.

are from Chamberlain.[9] Prior to acid treatment, the porosities of *A* and *B* were, respectively, 4.75 and 7.32 per cent, and their permeabilities were, respectively, 1.2 and 0.84 md. However, no explanation is given for the decrease in porosity of sample *B*, nor is it stated whether the porosity of *A* or *B* measured after treatment included the voids produced during the treatment.

The points marked *C*, *D*, *E*, *F*, *G*, *H* and I represent samples that contained small but plainly visible cavernous openings extending through the sample in the direction in which the permeability was measured. The points *H* and *I* represent the combined effects of caverns and good porosity in the matrix. The corresponding core samples were from Yates. The other cavernous samples had dense matrices of low porosity.

The point *S* refers to a cylindrical plug of sealing wax 1 in. long by 0.7 in. in diameter, through which a small coaxial hole had been pierced by means of a fine,

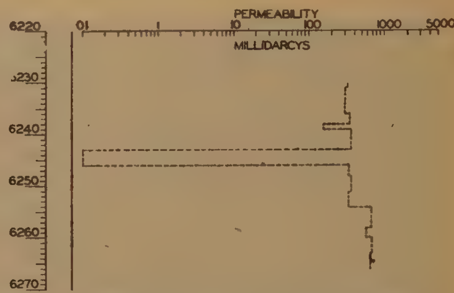


FIG. 4.—PERMEABILITY PROFILE, SAND WELL B, EAST TEXAS.

hot wire. It represents a permeable, foramenular porous medium in which the ratio of pore surface to pore volume is a minimum.

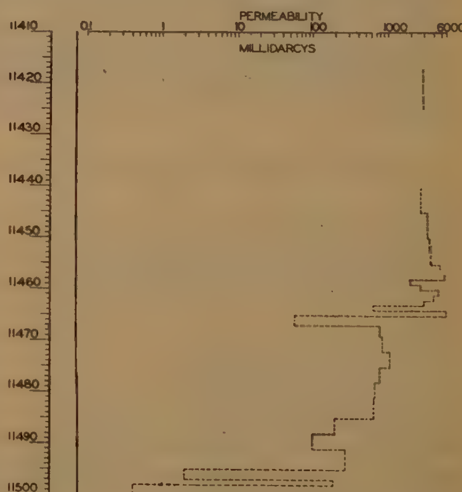


FIG. 5.—PERMEABILITY PROFILE, SAND WELL C, SOUTH LOUISIANA.

Relatively few points occur in the intermediate region below and to the right of the lower boundary, which corresponds to highly cavernous and/or fractured limestones; (1) because most of the fields represented probably do not contain zones of this kind and (2) because, where present

such zones are extremely difficult to core successfully.

It appears reasonable to conclude that the ratio of the pore surface to the pore

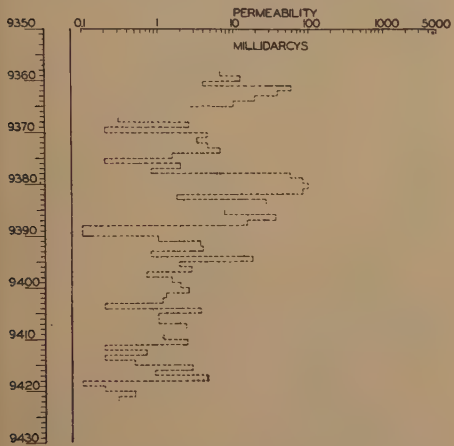


FIG. 6.—PERMEABILITY PROFILE, SAND WELL D, SOUTHEAST TEXAS.

volume in a specimen falling below and to the right of the boundary is smaller than in an intergranular specimen of the same porosity. If true, we would expect a difference in the capillary properties of the two types of media.

Fig. 2, or a similar but more numerous assemblage of points, could be of practical value for use in the correlation of the appearance of limestone samples under the microscope with their porosity and permeability; for it is evident that the position of each point represents not only the porosity and permeability of the sample, but also reflects the evolutionary processes the sample has undergone, and these, in turn, will have given to the sample a characteristic appearance.

Comparison of Vertical and Horizontal Variations of Permeability in Limestones and Sandstones

Figs. 3 to 6, inclusive, illustrate permeability profiles of four typical sandstone wells. Figs. 7 to 10, inclusive, are the profiles of four dolomitic limestone wells in West Texas. A logarithmic scale was used for plotting permeabilities, in order to permit representation of a wide range of values. Permeabilities of 0.1 md. or less

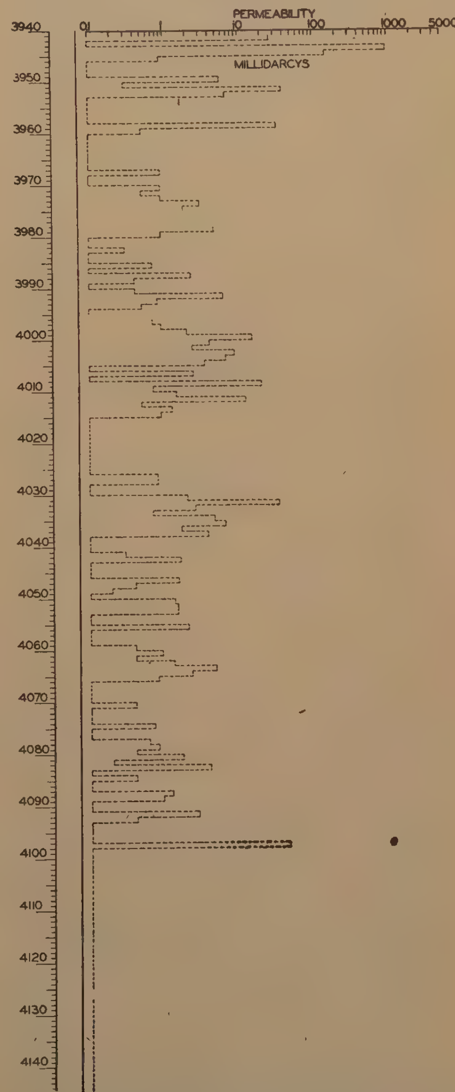


FIG. 7.—PERMEABILITY PROFILE, LIMESTONE WELL A, FOSTER FIELD, ECTOR COUNTY, TEXAS.

are all shown as 0.1 md. The limestone wells were selected to reflect a high degree of core recovery, consequently only rela-

tively intergranular, relatively noncavernous and, perhaps, nonfractured zones are represented.

It is interesting to observe that a very

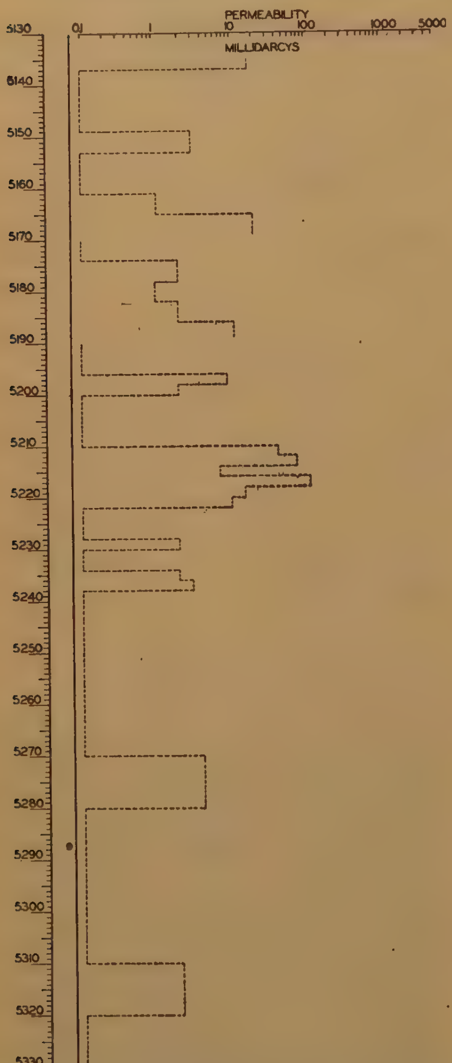


FIG. 8.—PERMEABILITY PROFILE, LIMESTONE WELL B, SEMINOLE FIELD, GAINES COUNTY, TEXAS.

large fraction of the penetration of even the permeable limestone formations is of 0.1 md. permeability or less, whereas in sandstones the zones of low permeability are thin relative to the zones of higher permeability, and constitute a small fraction of the pay. This statement is confirmed by the data of porosity and permeability

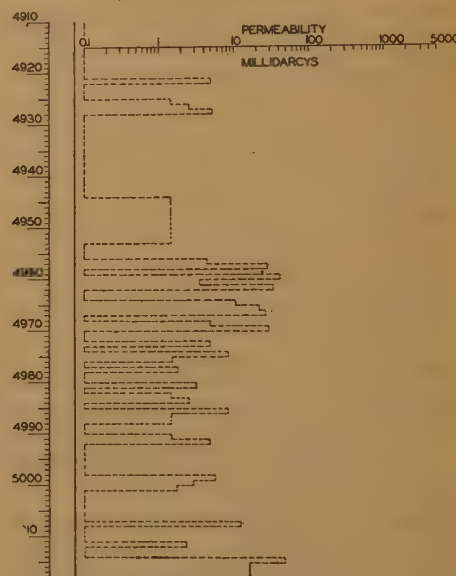


FIG. 9.—PERMEABILITY PROFILE, LIMESTONE WELL C, WASSON FIELD, YOAKUM COUNTY, TEXAS.

assembled for Figs. 1 and 2. Of the total sandstone data, 6 per cent were of permeability less than or equal to 0.1 md. whereas about 80 per cent of the available limestone permeability data were in this range. All the limestone cores were taken in the pay zones of the formations cored. Furthermore, the permeable zones in the limestones are of lower permeability on the average than similar zones in the sandstones. This is borne out by the scattering of data in Fig. 2.

Thin streaks of superior or inferior permeability are rarely correlatable between wells in limestone formations, although such correlation frequently is possible in sandstone formations; for in sandstones the form of the permeability profile is directly related to the original processes of sedimentation, the mineralogi-

cal composition of the sedimentary sequence, and to the manner of subsequent compaction and consolidation. This is probably true also of limestones (if due irregularity in their profiles. Evidently the cause, or causes, of such variations in permeability were absent in the evolution of most producing sandstones.

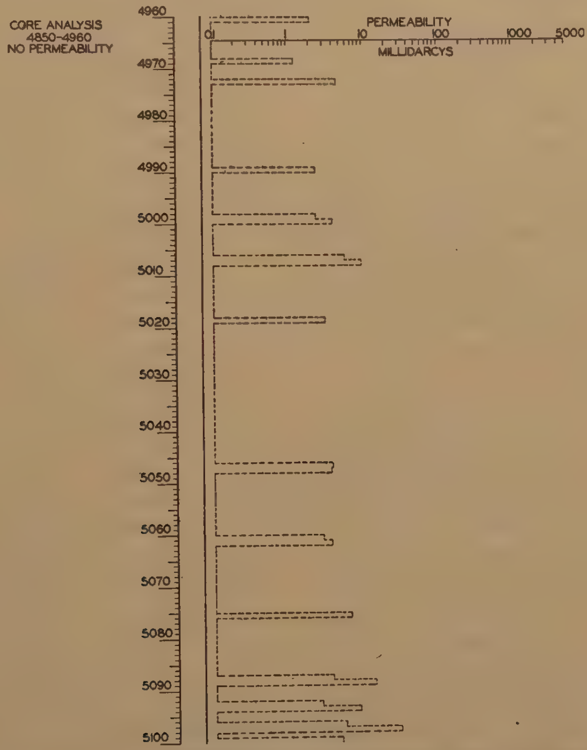


FIG. 10.—PERMEABILITY PROFILE, LIMESTONE WELL D, WASSON FIELD, YOAKUM COUNTY, TEXAS.

allowance is made for the fact that usually they are not clastic sediments), and, undoubtedly, if the geometry of their void systems were determined solely by such processes we should expect a similar relationship between the stratigraphy of the formation and its permeability profile. However, microscopic and chemical examination of many limestone formations with erratic permeability profiles fail to show that the variations in permeability are due to changes in sorting and size of the sedimentary units or to mineralogical changes. On the contrary, many limestones of apparent uniformity of crystal size and of a high degree of purity display considerable

It is not unreasonable to assume that the chief of these causes was the action of migrating ground water. Also, the ability of limestone to hold a fracture provides for the appearance of another type of similar highly permeable, erratically located passageway within the intergranular matrix.

Experience with producing limestone formations points to the conclusion that many of them consist of complexes of extensive low permeable bodies (intergranular media) interconnected by relatively thin zones of intermediate porous type of considerably greater permeability, or by fissures. From this type were derived the data of Figs. 7 to 10, inclusive. When

penetrated by wells these permeable zones and fissures appear to act as short-circuiting conduits, which open up to production distant regions of low permeability that otherwise would produce into the wells at impracticable rates. There is evidence that the improvement in productivity attendant upon the acidization of wells in this type of formation is due to the enlargement of these channels, and/or fissures, rather than to improvement of the permeability of the open section as a whole. Finally, the presence of such passages may nullify the benefits of pressure maintenance or water flood by unduly concentrating the flow of injected fluids. Little is known about the porous system of cavernous producing limestones because of the difficulty involved in coring them. However, the evidence indicates that this type consists of numerous large vesicular openings set in a relatively dense matrix, and interconnected by means of fine crevices, fissures and smaller penetrating, cavernous channels.* Nevertheless, in both types of formation the distribution of permeability is evidently less dependent upon sedimentation, stratification and structure than in sandstones and is, therefore, less predictable in undrilled regions. This appears to be the explanation for the extremely large differences between the potentials of offset wells in limestone fields that are structurally and stratigraphically equivalent.

Lower Limit of Permeability for Oil Production in Sandstones and Limestones

Comparison of Connate-water Saturations in the Two Types of Rock

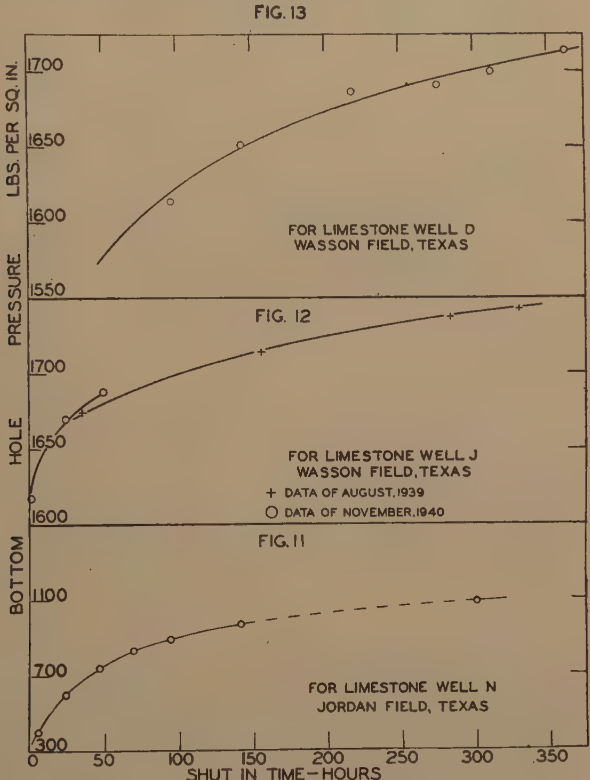
Generally, sandstones of permeability less than 1 md. do not produce commercial quantities of oil, regardless of the thickness penetrated. (Sand well *D*, Fig. 6, with an average permeability exceeding 1 md., is a condensate producer of low capacity.) By comparison, there appears to be evidence for believing that limestones of less than 0.1 md. permeability and of porosity as low as 4 per cent will produce oil.

Core analyses and examination of drill cuttings have revealed that the formations in such fields as Eunice, in New Mexico, Wasson, Slaughter, Goldsmith, Foster, Jordan and Westbrook, in Texas, to mention, but a few, contain large bodies of oil-bearing limestone of less than a few tenths of a millidarcy permeability. Furthermore, the recoveries to date from individual wells in these fields, or from the individual fields as a whole, tend to eliminate the possibility that only the permeable (i.e., greater than 1 md. permeability) zones are producing. The continuing productive life of the Westbrook field in Mitchell County is evidence in this direction. The fact that a well, such as limestone well *D*, Fig. 10, at Wasson, in which only 8.4 per cent of the pay (cored with nearly 100 per cent recovery) possessed a permeability exceeding 0.1 md., has produced 69,000 bbl. of oil for a decline from initial productive capacity of only about 20 per cent, is further evidence. This well was acidized at completion but apparently the effect was an increase in the permeability of existing permeable zones rather than a uniform increase in the formation as a whole.* This contention is substantiated by the laboratory work of Chamberlain[9] and by the results of Dowell electric-pilot surveys on near-by wells. As another illustration, the ultimate recovery of a well at Foster was predicted on the basis of net pay based on the footage of "good" (i.e., greater than 1 md.) permeability. The resultant figure already has been exceeded by 70 per cent, and the well is still producing its allowable.

* We are indebted to Mr. Paul Weaver, of the Gulf Oil Corporation, for a description of cavernous fragments ejected by wells in the Golden Lane region of Mexico.

* At completion this well bailed dry in 6 hr. after recovering 14 gal. of oil. Potential after 10,000-gal. acid treatment was 600 bbl. per day.

Additional evidence of a somewhat different kind is provided by bottom-hole pressure build-up curves of wells in these fields. For example, Figs. 11, 12, and 13 are into the zones of higher permeability and thereby continuously resaturated these lanes of communication with the well bore.



FIGS. 11–13.—BOTTOM-HOLE PRESSURE BUILD-UP.

such curves for one well at Jordan and two at Wasson. Fig. 11 represents a well in the Jordan field; Fig. 12, a well in the prolific central area of Wasson, while Fig. 13 is a curve for limestone well *D*, Fig. 10, in the northwest area of this field.* After being shut in for 350 hr., the pressure in well *D* had not reached equilibrium. It would appear that a good deal of energy and, therefore, oil also, was coming from the thick, low permeable bodies. This oil apparently migrated slowly from the dense

* The two Wasson pressures were measured during the state-wide shut-in period in Texas during August 1939.

The apparent contrast as regards minimum productive permeability between sandstones and limestones may be due to the difference in connate-water saturation in the two, since a high water saturation would be expected to reduce the relative permeability to oil. The connate-water content of low permeable sandstones, even when well above the water level, is generally high, whereas that of many low permeable limestones is, by comparison, low. It appears possible that the water saturation is approximately inversely proportional to the mineralogical purity of the limestone.

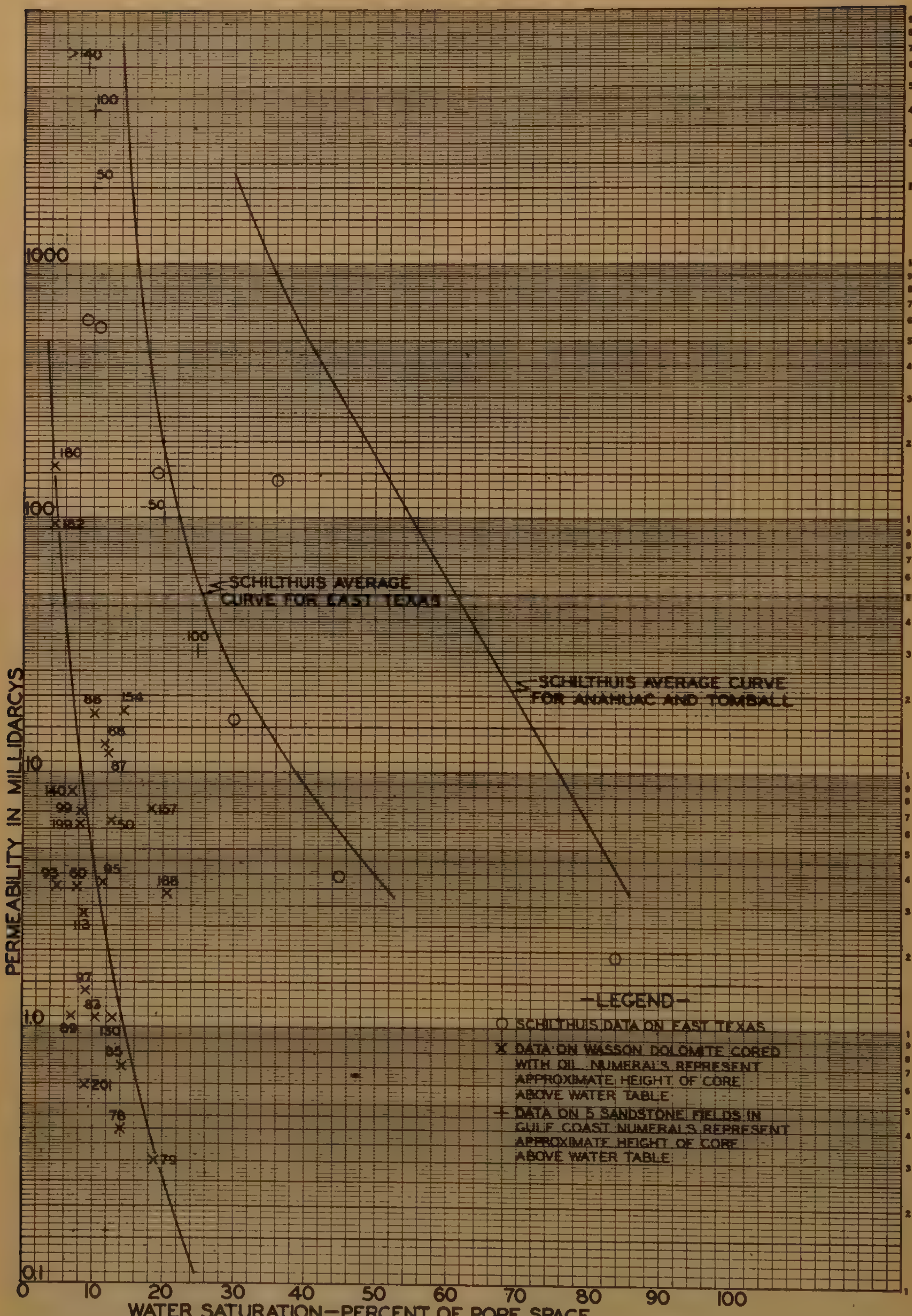


FIG. 14.—COMPARISON OF RESIDUAL WATER SATURATION IN SANDSTONE AND DOLOMITIC LIMESTONE CORES.

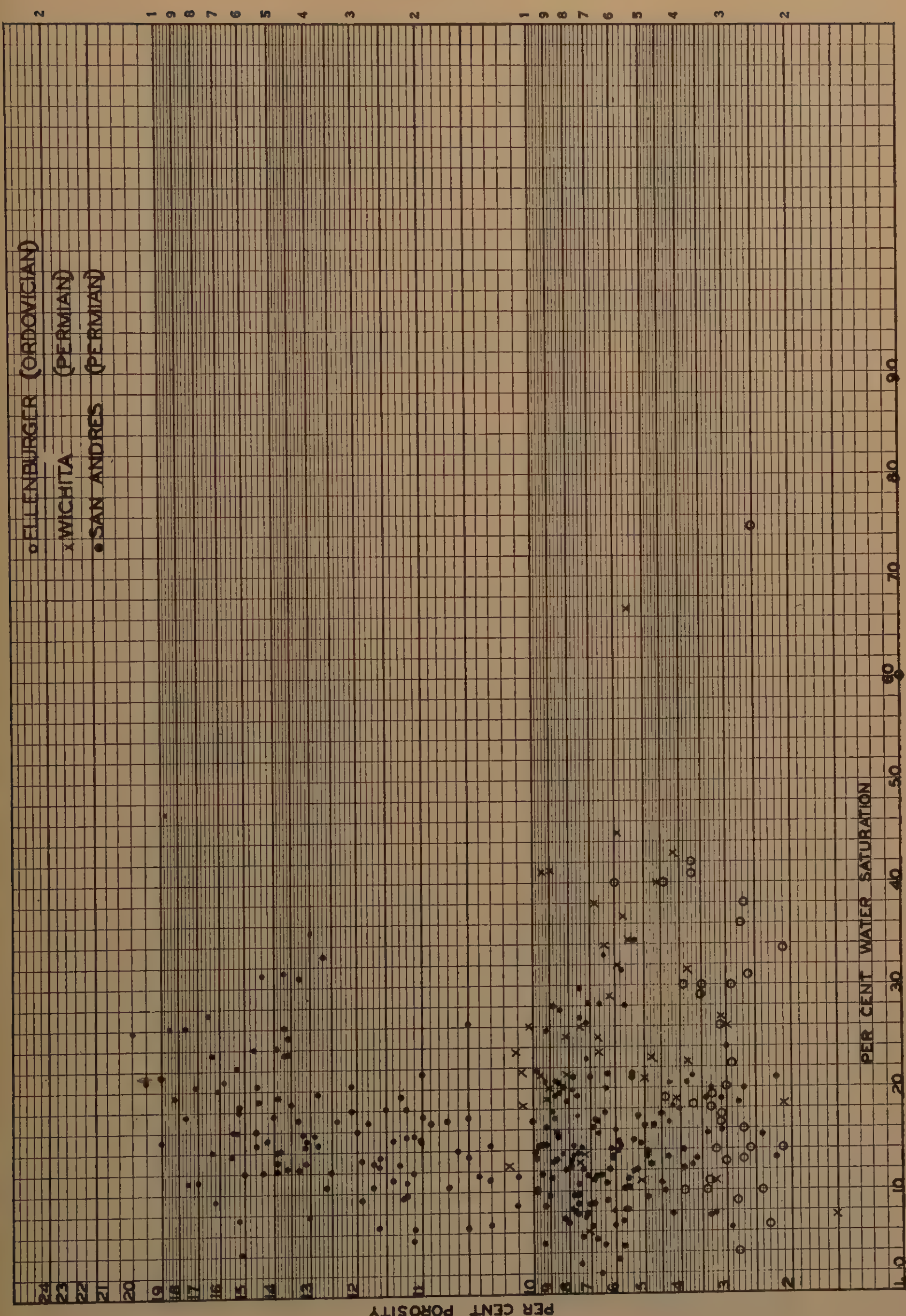


FIG. 15.—RELATION BETWEEN POROSITY AND WATER SATURATION IN CORES OF THREE DOLOMITIC LIMESTONES.

Fig. 14 shows the relation between water saturation and permeability for a number of cores from a well cored with oil at Wasson. Approximate height of each sample above the water level is represented by the numerals above the individual data. For comparison, some of the data on East Texas sands and the average curves for East Texas and Anahuac were taken from the paper by Schilthuis.[10] His data are not strictly comparable, in that many of the samples appear to have been in the zone of saturation lying between 100 per cent water and the true residual saturation. However, a few data were available on sandstones taken from levels well above the water in formations in the Texas and Louisiana Gulf Coast, and are sufficient to make a rough comparison with the limestone data. Fig. 15 shows the relation between porosity and water saturation in cores of three wells cored with water-base muds. The wells were completed, respectively, in the San Andres dolomite of Permian age, the Wichita dolomite of Permian age, and the Ellenburger dolomite of Ordovician age. Even without allowing for possible invasion of mud filtrate, the saturations are low on the average; in particular, we would call attention to the large number of saturations below 20 per cent in the porosity range below 10 per cent. The majority of the latter cores were of less than 0.1 md. permeability.

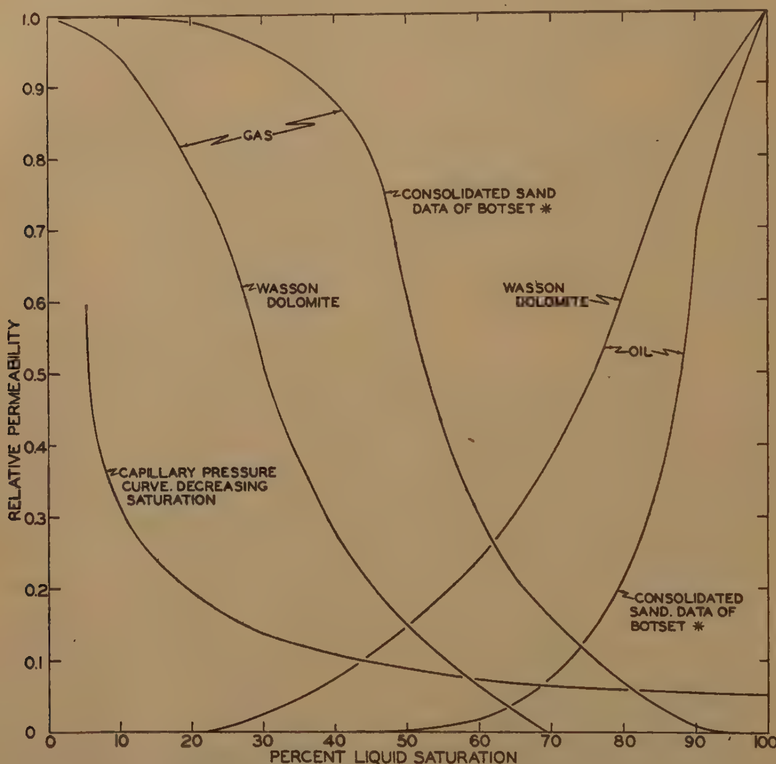


Fig. 16.—Comparison of relative permeability of Wasson dolomite and consolidated sand.
* Sand data taken from H. G. Botset.[11]

Comparison of Relative Permeability and Capillarity in Limestone and Sandstone

Our experimental data pertaining to relative permeability are derived from limestone cores with few and small non-intergranular openings, mostly of the vesicular type. Fig. 16 shows the relative permeability to oil and to gas, at moderate pressures of a Wasson dolomite specimen of 78 md. specific permeability and 23.6 per cent porosity.* Included for comparison are Botset's[11] data for a consolidated sand. The limestone core was selected as representative of a numerous group from the San Andres dolomite at Wasson. In Fig. 17 is shown the average relative permeability curve for 26 cores from three dolomite formations of Permian age in West Texas.

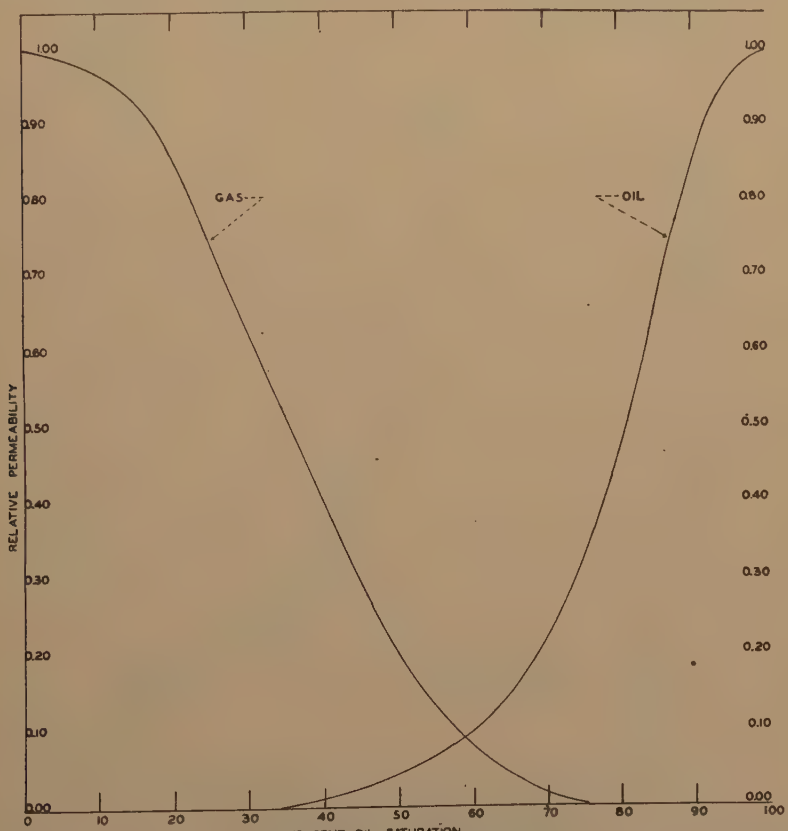


Fig. 17.—Average relative permeability for 26 cores from three Permian dolomites in West Texas.

From these data it appears that, on the average, the relative permeability to oil of limestones of moderately intermediate porous structure is higher for a given oil saturation than it is in sandstones.

Although no experimental data are available on highly intermediate limestones, several inferences may be drawn from indirect considerations. In cavities that are large compared with the original inter-

* Our relative permeability data were obtained from the unpublished research of the Shell Development Co., Emeryville, California, with whose permission they have been presented here.

granular channels, capillary forces will be lower; hence, separation of the phases will occur more easily. In addition, drainage and depletion of a single fluid will be more complete, the less disperse and interconnected the total void space. Where the bulk of the oil is held in fractures or solution caverns that have access to the well, very low primary depletion saturations are to be expected, and in formations where such conditions are suspected, secondary recovery should be approached warily.

As regards capillary phenomena in moderately intermediate dolomitic limestone, the data of Hassler, Brunner and Deahl,[12] appear to indicate an appreciable difference from that of sandstones. Some of their results are reproduced in Figs. 18, 19 and 20.

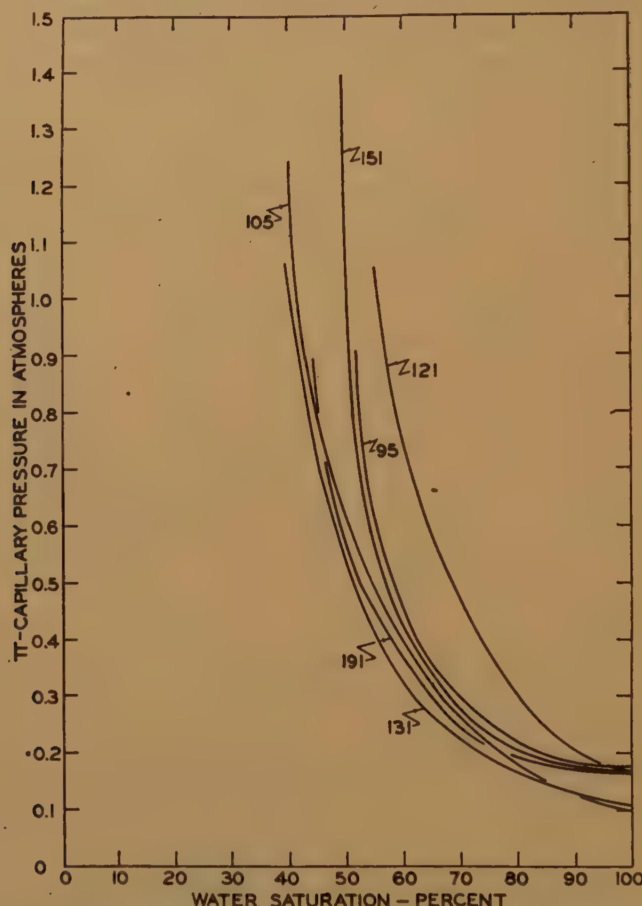


FIG. 18.—CAPILLARY PRESSURE OF SANDSTONES FROM A CALIFORNIA FIELD.

Figs. 18 and 20 show curves for capillary pressure vs. water saturation for a number of sandstone cores from California and the Mid-Continent, respectively. Fig. 19 gives similar curves for six cores from the San Andres dolomite in Wasson. The numerals beside the curves represent the permeability of the corresponding core sample, in millidarcys. On the average, the residual water saturations of the Wasson cores are lower than those for the two groups of

sandstones, while two of them, one of which had a specific permeability of only 12 md., achieved residual water saturations of about 5 per cent.

less than 25 per cent if the surface tension of the formation oil could be maintained at the low values obtained by Katz, Monroe and Trainer.[13]

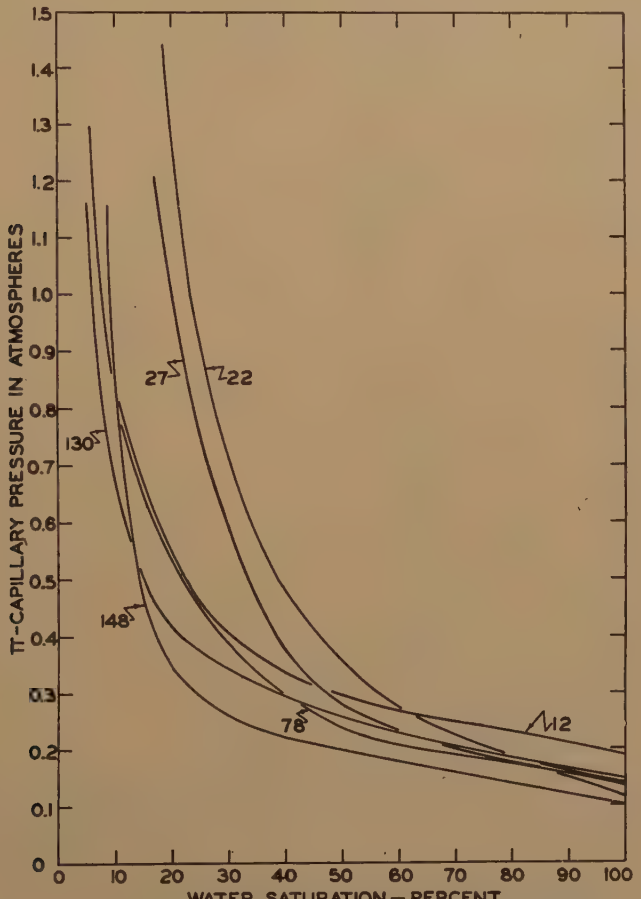


FIG. 19.—CAPILLARY PRESSURE OF DOLOMITIC LIMESTONE SPECIMENS FROM A TEXAS FIELD.

Although these results are derived from only a few samples from one limestone formation, the similarity as regards other properties of the relatively pure dolomites leads us to believe these results are not unique. If we assume further that equally low residual oil saturations could be achieved, the depletion oil saturation, for this formation at least, will probably be lower than in sandstones, and might be

It is hardly necessary to add that capillary retention in highly intermediate formations would probably be low by virtue of the fact that the ratio of pore surface to pore volume in such formations is lower than in sandstones, whereby the fluid surface itself is broken up into fewer separate small elements, which cling to the walls of the pores and thereby resist movement of the liquid.

CONCLUSIONS

In addition to the tentative conclusions already stated, we would append the following:

1. Application of the classical mathematical analysis of flow to intermediate limestones is of doubtful value—in highly intermediate limestones, because the generalized form of Darcy's law (p. 129 of ref. 6) does not hold; and in moderately intermediate limestones because it is practically impossible to take into account the geometry of the system of internal boundaries,* which divide the reservoir into numerous (probably depletion type) sub-reservoirs of low permeability.† What appears to be required is a change in viewpoint from the methods that represent the core as the fundamental element from whose behavior that of the whole formation may be "integrated," to one that recog-

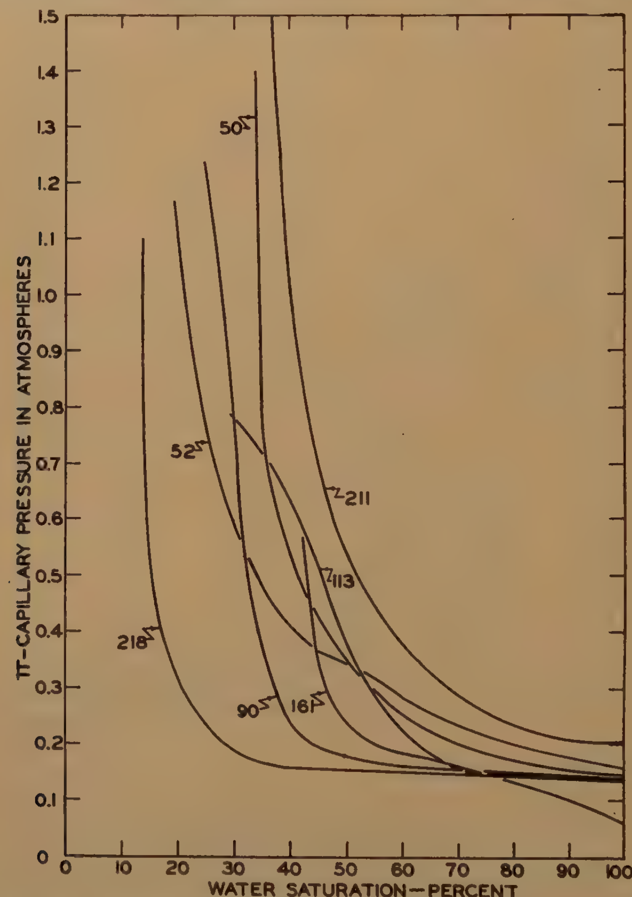


FIG. 20.—CAPILLARY PRESSURE OF MISCELLANEOUS MID-CONTINENT OIL-FIELD SANDSTONE. Permeability plugs (benzene extracted) were measured with water. The figures give the permeability in millidarcys.

* Thin permeable zones, or fissures.

† Furthermore, the recent work of Wentworth[14] indicates that large and significant deviations from Darcy's law may take place in the flow of fluids in a complex system of numerous fine fractures.

nizes the entire producing formation as the irreducible unit.*

2. The material-balance method fails to be entirely satisfactory in moderately intermediate limestones because the slow approach of such reservoirs to equilibrium pressure renders it difficult to determine the true pressure on the basis of shut-in periods of practicable duration.

3. Careful analysis of production and bottom-hole pressure records in conjunction with the results of geological study, the phase-equilibrium data of the reservoir fluids, and data of core analyses is the minimum requirement for an understanding of the reservoir performance of limestone formations. In particular, complete coordination of the geological and physical data is necessary in order to accomplish this purpose.

4. In many limestone fields, a considerable part of the oil appears to be held in and produced from thick zones of permeability less than 0.1 md. The rate at which these regions produce into the permeable zones that connect them with the well depends, among other things, upon the pressure gradient across the boundary between the two. It is, therefore, advantageous to maintain this gradient at a high value if primary depletion of the low permeable zones is to be complete. Consequently, since pressure maintenance would have the effect of partly or wholly nullifying this gradient, such secondary recovery operations should not be applied indiscriminately.

* The method of W. A. Bruce,[15] for example.

Acknowledgments

We wish to thank the Shell Oil Company, Incorporated, for permission to publish this paper, and the Shell Development Company for the use of some of its unpublished data. We are particularly indebted to Mr. C. G. Cooper, of the Shell Oil Company, Incorporated, for his advice and assistance in its preparation, to Mr. M. A. Westbrook, of the Shell Production Laboratory, for a number of important measurements, and to Mrs. Roy Hollar, Librarian of the Midland County Library, for her help in securing necessary references.

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Chapter II. Petroleum Economics

Estimated Consumption of Petroleum Products in the United States after the War

By C. L. Burrill*

(New York Meeting, February 1944)

The forecasts presented in this paper constitute an attempt by the writer to predict the *pattern* of the consumption of petroleum products in the United States during the period of transition from war to peace. Although, in preparing the estimates, secular trends were not overlooked, greater emphasis was placed upon considerations of a cyclical character, or upon influences which might be peculiar to parts of the period. The estimates do not extend beyond the year 1950 because by then conditions in the industry should have returned to normal.

The consumption of petroleum products is affected, of course, by changes in the condition of business in general. Before estimates of petroleum consumption could be prepared, therefore, it was necessary to predict the pattern of general business during the period under review, particularly the economic series that in the past have shown the closest relationships with petroleum consumption.

It is the writer's view that business activity in this country (as measured by industrial production) will be higher on the average during the period between the end of the war and the year 1950 than it ever was before during a peacetime period of the same duration. When the war is over, consumers will have saved amounts of money that will be very large as compared with any previous accumulations. There is little question, therefore, as to the financial *ability* of consumers to purchase goods. The production of many durable consumers' goods, such as automobiles, refrigerators and radios, has been completely stopped since early in the war; also, many semidurable and nondurable consumers' goods have not been available in the quantities or the qualities desired. There is considerable *need*, therefore, for consumers to purchase goods after the war. The important question is whether consumers *will* purchase goods in large enough quantities to keep our economy running at a high level. The writer answers this question in the affirmative. The mere existence of very large consumer savings lends considerable support to this view because, with such backlogs of "security," consumers can afford to spend more of their current earnings than they otherwise could. Also, several polls have been taken, which indicate that consumers expect to buy large quantities of a variety of goods. Some of the savings, therefore, probably will go into current consumption. Even though this percentage is relatively small, so that the bulk of the funds accumulated by consumers during the war continues to remain as savings during the period under review, spending should be great enough to start the production cycle and keep it

Manuscript received at the office of the Institute Feb. 24, 1944. Issued as T.P. 1730 in Petroleum Technology, July 1944.

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going at a relatively high rate for a fairly extensive period.

In fact, some analysts believe that consumers will wish to spend so much of their war savings that drastic inflation is likely. The writer does not share this view, because it assumes that production will be insufficient to meet the demands of consumers. Although this may be true for a few articles in the immediate postwar period, it is not likely to be true very long in view of the potential producing capacity of this country after the war. Furthermore, it is unlikely that consumers will want to spend all, or even a large part, of their war savings in the critical period when industry is reconverting plants to civilian production. Many will exhibit a cautious point of view because conditions are unsettled and families are changing locations. Others will not want to purchase the goods immediately available in the hope that, by waiting, goods embodying newer developments, or goods of better quality, can be obtained. In general, it is the writer's view that many consumer demands will be satiated sooner than most people have been led to believe, and that manufacturers and distributors may be faced with a buyers' market not too long after reconversion has been completed. The writer believes that although drastic inflation is not likely to take place, prices will, on the average, be higher than they were before the war.

Although the reasons are somewhat different, it is the writer's view that, on the average, producers also will be able to purchase, will need to purchase, and will be willing to purchase large quantities of goods.

Based upon the reasoning outlined, the writer estimates that the Federal Reserve Board index of industrial production (in peacetime the most useful index of business activity for purposes of forecasting petroleum consumption), as now constituted, will drop from the current level of 245 (1935–1939 = 100) to an average of 140 during the first full year after the end of the war, and will then rise to an annual peak of 175 near the end of the period under review. On the assumption that the war in Europe will end in late 1944, and the war in Asia a year later, the specific forecasts, compared with some prewar years, are given in Table 1.

TABLE 1.—*Comparison of Federal Reserve Board Indexes of Industrial Production*

Actual		Forecast	
Year	F.R.B. Index	Year	F.R.B. Index
1937	113	1944	245
1938	89	1945	190
1939	109	1946	140
1940	125	1947	150
1941	162	1948	160
1942	199	1949	170
1943	239	1950	175

The estimated level of industrial production after the war is considerably higher than prewar levels and is about the same on the average as production during the year 1941, of which approximately 10 per cent was attributable to war goods. It is probably reasonably accurate to assume that production in 1941 was not far below our peacetime capacity on a 40-hr. week, and with one-shift operation. After considering increases in capacity during the war, the average level estimated for the postwar period is probably below our postwar productive capacity (but not greatly so) on a 40-hr. week with typically one-shift operation. This level is considerably above a good prewar year such as 1937.

So much for the general conditions upon which the petroleum forecasts have been based. In discussing the petroleum estimates, each major product has been considered separately. Tabulations by years are shown for each major product covering the years 1941–1950 inclusive, and indicate, as far as possible, the con-

sumption by principal uses. In preparing the estimates, it was necessary, of course, to make many assumptions, the more important of which are listed below:

1. The war will be over in Europe by the end of 1944, and in the Far East by the end of 1945.

2. A substantial amount of reconversion of facilities to the production of civilian goods will take place in the year 1945, and some passenger cars for civilian use will be manufactured.

3. Restrictions upon the consumption of petroleum products will be partially removed during 1945, and will be entirely removed by the end of that year.

4. Government control over the prices and qualities of petroleum products and over tanker rates will be removed by the end of 1945.

5. Consumption of gasoline by passenger cars will not be seriously limited by the availability or quality of tires after Jan. 1, 1945.

6. Consumption of gasoline by trucks and buses will not be limited by the availability of tires after July 1, 1946.

The importance of these assumptions in estimating consumption of petroleum products is obvious, but some comment upon their validity is desirable. Item 1 is a guess. The extent of reconversion that may take place as indicated in item 2 depends chiefly upon the requirements of the military establishment, but it seems reasonable to expect that military requirements will be reduced substantially in 1945 and that in order to maintain employment everything possible will be done to take up the slack by producing civilian goods. The writer is aware of the difficulties involved in carrying out partial reconversion on an equitable basis and believes that the estimated production of 1,000,000 passenger cars is the maximum that should be expected in the year 1945. Items 3 and 4 relate particularly to gasoline and fuel oils. Some reduction in military requirements should take place when the war in Europe is over, thereby making more of these products available for civilians in 1945. Price controls, if maintained after the war is over in Asia, might limit the consumption of fuel oil (particularly heavy fuel) and might tend to retard reconversion to oil from coal. The writer sees no need for maintenance of these controls after the war is over, because supplies will be adequate to meet the expected demands.

Assumptions 5 and 6 are based upon the latest information the writer has been able to obtain on the expected availability of synthetic rubber for passenger tires, of crude rubber for truck and bus tires, and the availability and quality of tires. It is assumed that by 1945 there will be adequate supplies of synthetic rubber to meet all needs, and the capacity to produce passenger-car tires will be considerably greater on a peacetime basis than it was before the war. Perhaps capacity on a peacetime basis will be as large as 90,000,000 passenger tires per year. The quality (measured in terms of mileage at normal driving speeds) of synthetic passenger-car tires is taken to be approximately 85 per cent of first-line tires made of crude rubber.

To date fully satisfactory truck and bus tires have not been made from Buna-S synthetic rubber; therefore assumption 6 was made to allow for the possibility of restrictions upon the use of truck and bus tires (and hence gasoline consumption by such vehicles) until crude rubber can be provided for this purpose. Although this may appear to be too pessimistic a view, it is probably the safest one.

In the discussion of individual products presented in the following pages, the tabulations of the forecasts cover the years 1941–1950 inclusive. For reasons of national security, it was not possible to show estimates of domestic consumption by uses for the assumed war years, 1942–1945 inclusive, or estimates of exports for the same period.

Postwar Consumption of Gasoline

The production of gasoline in this country today is less than the monthly peak production reached in December 1941, yet 30 to 40 per cent of the total is being used for military purposes in the form of aviation gasoline or all-purpose automotive fuel. Civilian consumption necessarily has been reduced considerably in order to make available such large quantities for the armed forces. The important question regarding postwar consumption of gasoline, therefore, is how soon civilian consumption will increase enough to offset the inevitable reductions in military requirements. The most important single use of gasoline is in passenger cars; these estimates are shown in the top line of Table 3.

Table 2.—*Estimated Number of Passenger Cars in Use and Gasoline Consumption by Passenger Cars*

Year	In Use Jan. 1	New Registrations	Total Registrations	Scrapped	In Use Dec. 31	Average in Use	Gasoline Consumption, Barrels (42 Gal.)	
							Per Car	Total
1941	25,910,492	3,731,166	29,641,658	1,972,601	27,669,057	26,789,775	16.6	445,000,000
1942	27,669,057	400,000	28,069,057	3,000,057[b]	25,069,000	26,369,000	12.5	330,000,000
1943	25,069,000	300,000	25,369,000	1,700,000[c]	23,669,000	24,369,000	9.9	242,000,000
1944	23,669,000	1,000,000[a]	24,669,000	1,500,000	23,169,000	23,419,000	10.5	246,000,000
1945	23,169,000	{1,700,000[a] 1,000,000}	25,869,000	1,800,000	24,069,000	23,619,000	13.5	319,000,000
1946	24,069,000	4,000,000	28,069,000	2,000,000	26,069,000	25,069,000	16.0	402,000,000
1947	26,069,000	6,000,000	32,069,000	3,000,000	29,069,000	27,569,000	18.5	510,000,000
1948	29,069,000	5,000,000	34,069,000	3,500,000	30,569,000	29,819,000	18.5	552,000,000
1949	30,569,000	4,000,000	34,569,000	3,000,000	31,569,000	31,069,000	18.0	559,000,000
1950	31,569,000	3,000,000	34,569,000	2,500,000	32,069,000	31,819,000	18.0	572,000,000

[a] Brought out of dead storage.
[b] Estimated 2,000,000 laid up and 1,000,000 scrapped.
[c] Estimated 700,000 laid up and 1,000,000 scrapped.

Table 3.—*Estimated Demand for Gasoline in the United States*
1000 Barrels of 42 Gallons Each

Year	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Domestic demand:										
Passenger cars	445,321	329,992	242,400	246,000	319,000	402,000	510,000	552,000	559,000	572,000
Trucks and buses	149,000					140,000	150,000	160,000	170,000	180,000
Agriculture	25,000					30,000	30,000	30,000	30,000	30,000
Aviation	12,756					17,000	17,000	20,000	25,000	30,000
Misc. and losses	38,500					31,000	32,000	32,000	36,000	38,000
Total	670,577					620,000	739,000	794,000	820,000	850,000
Exports—automotive:										
North America						2,000	3,000	4,000	5,000	5,000
Europe						5,000	3,000	2,000	1,000	
Asia						6,000	4,000	2,000	1,000	
Oceania						4,000	3,000	2,500	2,000	1,500
Total						17,000	13,000	10,500	9,000	6,500
Exports—aviation:										
North America						500	1,000	1,000	1,500	1,500
Europe						1,000	2,000	3,000	3,000	3,000
Asia						5,000	2,000	1,000		
Oceania						6,000	2,000	1,000	1,500	1,500
Total						12,500	7,000	6,000	6,000	6,000
Total exports	24,076					29,500	20,000	16,500	15,000	12,500
Total demand	694,653	624,092	617,700	700,000	675,000	649,500	759,000	810,500	835,000	862,500

Passenger Car Consumption

In order to estimate consumption of gasoline by passenger cars, it is necessary

to estimate the average number of cars in use and the average consumption per car. The first of these two steps involves estimates of passenger-car production and scrappage during each year, which are shown in Table 2.

As shown by the figures of Table 2, the writer has been conservative in estimating scrappage during the war period, on the theory that, with less driving and lower speeds, cars would wear out less rapidly. Also, car owners would tend to take better care of cars, knowing that the latter could not be replaced for several years. This conservatism was given some support by the O.P.A., which stated early in 1943 that the number of cars in use, based upon *A* cards issued, was approximately 25,000,000. For the later years of the period, after car production has again reached substantial levels, the estimate of scrappage was increased to a level considerably above the prewar average, in order to reduce the average age of the vehicles in use to a figure comparable with prewar experience.

Estimates of new car registrations are forecasts of passenger-car production during the years 1946–1950 inclusive. In the other years the figures are a combination of registrations of new cars produced prior to March 1942, registrations of old cars brought out of dead storage and, in the year 1945, the production of 1,000,000 new cars. Peak production in the postwar period is estimated at 6,000,000 cars in 1947. Thereafter, production declines to 3,000,000 in 1950. On the basis of these estimates, the average number in use in 1950 is estimated as 31,800,000, which does not appear to be excessive in view of the high levels of business activity expected by the writer.

The estimates of consumption per car used in calculating the total consumption by passenger cars are as given in Table 4.

The low estimates during the war period reflect the effect of rationing. For 1945, after completion of the war in Europe, consumption per car was increased considerably, on the assumption that rationing would be relaxed, but not eliminated. Beginning in 1946, the estimates reflect only physical or economic factors that would influence consumption, and contemplate no rationing.

TABLE 4.—*Estimated Consumption per Passenger Car per Year*

YEAR	BARRELS (42 GAL.)
1941	16.6
1942	12.5
1943	9.9
1944	10.5
1945	13.5
1946	16.0
1947	18.5
1948	18.5
1949	18.0
1950	18.0

Consumption per passenger car in the postwar period will be affected by a number of factors, not all of which will act in the same direction. Those tending to increase the consumption per car are as follows:

1. Gasoline will be plentiful, whereas in the immediate post-war period the supply of some commodities (such as automobiles, radios and refrigerators), which normally compete for a share of consumers' dollars, will be inadequate. Until reconversion is complete, therefore, gasoline may obtain a greater than normal share of consumers' expenditures.

2. Consumers will have large savings and may spend more of current income.

3. Cars will be older and, to the extent they are run, will probably consume somewhat more gasoline per mile of travel. As new cars appear in large numbers, the effect of this factor will disappear.

4. There may be a large amount of automotive travel by families returning to their homes from war production centers.

5. Construction of superhighways, as public works projects designed to reduce unemployment, may tend to increase consumption per car.

6. For a short period of time after restrictions are lifted, people may drive

more than they otherwise would, just to be driving.

Factors that will tend to reduce the consumption per passenger car are as follows:

1. In the immediate postwar period the annual mileage (and therefore the consumption per car) may be restricted, because passenger cars will be in poor repair and mechanics may not be available to make the necessary repairs even though (as the writer expects) repair parts may be available in adequate quantities. After the first postwar year there should be no problem on this score.

2. The generally unsettled conditions during the period of reconversion, while war workers are shifting to civilian industries and soldiers are still being demobilized, may create a cautious attitude in the minds of many people, thereby tending to restrict vacation travel, which is essential to a high consumption per passenger car.

3. In later years of the period under review (1949 and 1950) the effect of new passenger cars designed to give greater economy may tend to reduce the average consumption per car.

The factors tending to increase consumption per car will, in general, outweigh the factors tending to decrease consumption, but during the first postwar year conditions are likely to be too uncertain for peak consumption. In the second postwar year, however, most favorable factors should combine to give an all-time peak consumption per passenger car. Thereafter, new car design may become a sufficiently important factor to prevent any further rise and perhaps to cause a decline in the consumption per car. This reasoning accounts for the drop in the estimates during the later years of the period, but it is important to notice that for 1950 the estimate of consumption per car is greater than the previous peak reached in 1941.

Using these estimates of passenger cars in use and consumption per car, the writer obtained the estimates of gasoline consumption shown in the first line of Table 3, which indicates a demand in 1946 of 402,000,000 bbl. (9.5 per cent less than in 1941), and 572,000,000 bbl. in 1950 (28.5 per cent greater than in 1941). The largest increase in any year over the previous year is estimated for 1947, when large increases in both the number of cars and the consumption per car combine to give an increase of 108,000,000 bbl., or 27 per cent.

Exports of automotive-grade gasoline are expected by the writer to show a steady decline during the period as other areas become more economical sources of supply.

Truck and Bus Consumption

The estimates of consumption by trucks and buses shown in line 2 of Table 3 are not based upon an analysis similar to that just described for passenger-car consumption, chiefly because the available facts upon which to base estimates are even less reliable for trucks than those available for passenger cars. Estimates of gasoline consumption by uses have been published infrequently in the past, and at best are estimates based upon rather small samples. The breakdown of passenger-car, truck and bus and agricultural demand given for 1941 is approximately the same as the estimate published by the Bureau of Public Roads. In making the estimates the writer tried to reflect the effect of high levels of business activity and the continued expansion of truck and bus transportation on the one hand and the growth in the use of diesel engines on the other. While it is recognized that other factors may tend to reduce consumption per unit, it is not believed these will have an important effect during this period. Therefore, the writer believes that the estimates of consumption of gasoline by trucks and buses shown are, if anything, conservatively low. A rough check obtained by dividing the estimates of consumption by

estimates of the average number of trucks in use indicates a slowly declining consumption per average truck from 1946 to 1950.

Agricultural Consumption

During the war agricultural income has increased greatly over prewar levels. Farmers have reduced their debts substantially, and there has been considerably less speculation in farm lands than there was during the last war. As a result, farm savings have increased to the highest levels in history. In view of this fact and the prospect that business activity will be high, it is reasonable to expect that farmers will have the financial ability to purchase larger than normal quantities of mechanical equipment. Since gasoline-consuming equipment will constitute a part of these purchases, the estimate of agricultural consumption of gasoline indicates an increase from 25,000,000 bbl. in 1941 to 30,000,000 bbl. in the postwar years.

Aviation Gasoline Consumption

There is little information available upon which to base estimates of consumption of aviation gasoline since statistics of production and stocks were shown separately by the Bureau of Mines for only a short period before the war. These meager statistics indicate that prewar consumption was very small compared with that estimated at present, and a large reduction in demand is to be expected, therefore, even though postwar consumption is several times the prewar rate. The writer's estimates may appear low to many people in view of the optimistic statements that have been published about postwar aviation. The comparison of 17,000,000 bbl. in 1946 and 12,756,000 bbl. in 1941 is probably misleading, however, because in 1941 estimated governmental consumption was 5,600,000 bbl., which was three times the amount used in 1940 and four and one-half times that consumed by the government in 1939. Also, in 1941, approximately 3,000,000 bbl. was used for training purposes in addition to the amounts for that purpose that might be included in the governmental figure. It is estimated, further, that approximately 1,000,000 bbl. was consumed in testing engines. Only 2,500,000 bbl. of the 1941 total domestic consumption, therefore, can be attributed to civilian uses. Scheduled airlines used approximately 2,000,000 bbl. and private flying accounted for only 500,000 bbl. in 1941. The estimate of 17,000,000 bbl. for 1946, therefore, would allow for a consumption by scheduled airlines of three times the 1941 rate, four times the consumption by private flyers in 1941, and still leave 9,000,000 bbl. for engine builders, for training, and for other military use. Because of the large number of pilots available in 1946, there should be very little consumption for training purposes. Also, engine builders probably will use very little, so that the entire 9,000,000 bbl. can be used by the armed forces. This is seven and one-half times the amount used for that purpose in 1939.

The estimate for 1947 is held at the 1946 figure because the writer expects that military consumption will decline while civilian consumption increases in equal amount. Beyond that year substantial annual increases are shown, so that by 1950 consumption is estimated at 30,000,000 bbl. If 7,000,000 bbl. of this is considered military consumption, the remainder would be nine times the 1941 consumption by scheduled airlines and private flyers.

Estimates of exports of aviation gasoline to Asia and Oceania are relatively high for 1946 and 1947, on the assumption that manufacturing facilities in the Near East and Far East will not be able completely to meet the demand in those areas until 1947. Also, it is expected that some military consumption will remain for a short period after the war in Asia is won. Exports to Asia are eliminated by 1949, but some

exports to Oceania are retained to supply eastbound transport planes from Hawaii. Exports of aviation gasoline to Europe are increased over the period, chiefly to supply westbound transport planes from the United Kingdom. These estimates give a total demand for aviation gasoline of 29,500,000 bbl. in 1946; 24,000,000 bbl. in 1947, and 36,000,000 bbl. in 1950.

Demand for All Purposes

The estimates of total demand for all gasolines indicate a figure of 649,500,000 bbl. in 1946, which is only 6.5 per cent less than the prewar peak demand reached in 1941. A sharp increase, almost entirely attributable to consumption by passenger cars, is indicated for 1947, and by the end of the period total demand is estimated at 862,500,000 bbl., which is 24 per cent greater than it was in 1941.

Postwar Consumption of Residual Fuel Oil

In the past the domestic demand for residual fuel oil has exhibited a close correlation with the Federal Reserve Board index of industrial production. During the war the usefulness of this relationship has been reduced because of the large increase in naval requirements and because substantial numbers of fuel oil burners have been converted to coal. In making the postwar estimates for this product, therefore, it was necessary to consider naval requirements and the reconversions from coal to oil separately. The estimates (Table 5) indicate the expected consumption by the navy, for heating purposes, and for all other purposes (chiefly industrial and marine bunkers).

On the assumption used in making the estimates of "all other" consumption—namely, that no taxes or additional import duties will be imposed in order to discourage the consumption of residual fuel—the writer expects that the past close relationship between the consumption of this product and industrial production will reassert itself after the war, and the estimates shown are calculated from prewar correlations, using the estimates of the F.R.B. index given in Table 1.

Table 5.—*Estimated Demand for Residual Fuel Oil in the United States*
1000 Barrels of 42 Gallons Each

Year	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Domestic demand:										
Navy	23,300					40,000	30,000	30,000	30,000	30,000
Heating oil	46,700					53,000	53,000	55,000	58,000	60,000
All other	315,339					300,000	310,000	319,000	328,000	333,000
Total	385,339					393,000	393,000	404,000	416,000	423,000
Less: Conversions to Coal	2,000					40,000	20,000	10,000	10,000	10,000
Net Domestic	383,339					353,000	373,000	394,000	406,000	413,000
Exports	13,828					13,000	10,000	6,000	4,000	2,000
Total demand	397,167	412,619	468,700	479,800	432,700	366,000	383,000	400,000	410,000	415,000

Consumption by the Navy prior to the outbreak of the war in Europe was approximately 10,000,000 bbl. per year. In view of the much larger navy, consumption after the war is estimated at 30,000,000 bbl. after the transition year 1946, when a higher estimate of 40,000,000 was used. These figures may be too high to the extent that our fleet is fueled from foreign supplies, but, since that possibility is uncertain at present, it has not been considered. Consumption for heating purposes has been increased moderately over prewar levels in line with past trends.

Although some reconversions of outlets that shifted to coal will probably take place before the war is over, it is estimated that former consumers of 40,000,000 bbl. annually will still remain as coal con-

sumers in 1946. This figure is cut in half in 1947, and again in half in 1948. Thereafter it is believed that reconversion will cease, leaving 10,000,000 bbl. of prewar outlet permanently on a coal-burning basis.

These estimates (Table 5) indicate a domestic demand in 1948 slightly greater than the actual consumption in 1941. By 1950 domestic demand of 413,000,000 bbl. is indicated, which is 7.7 per cent greater than in 1941, the peak prewar year. Exports of residual fuel are nominal and are expected almost to disappear by 1950. The total demand estimates show a figure in 1950 approximately 5 per cent greater than in 1941.

TABLE 6.—*Estimated Number of Burners in Use and Their Consumption of Heating Oil*

Year	Burner Sales	Replacements and/or Junked	Conversions	Reconversions	In Use End of Year	Average in Use	Consumption of Oil, Bbl. (42 Gal.)	
							Demand per Burner	Demand
1935	150,510	12,498			1,152,125	1,083,119	50	54,227,000
1936	220,075	31,525			1,340,675	1,246,400	56	69,249,000
1937	210,740	20,870			1,530,545	1,435,610	57	81,235,000
1938	179,360	42,160			1,667,745	1,599,145	52	82,388,000
1939	236,140	41,555			1,862,330	1,765,038	55	97,131,000
1940	302,210	29,415			2,135,125	1,998,728	58	115,533,000
1941	333,250	56,315	10,000		2,402,060	2,268,593	53	120,908,000
1942	99,514	25,284	90,000		2,386,290	2,434,438	50	121,506,000
1943	33,445	31,325	17,965	14,010	2,384,455	2,376,848	45	106,000,000
1944	25,000	50,000			2,359,455	2,371,955	45	106,000,000
1945	50,000	75,000			2,334,455	2,346,955	47	110,000,000
1946	200,000	75,000		60,000	2,519,455	2,426,955	54	131,000,000
1947	400,000	75,000			2,844,455	2,681,955	54	145,000,000
1948	400,000	75,000			3,169,455	3,006,955	54	162,000,000
1949	350,000	75,000			3,444,455	3,306,955	52	172,000,000
1950	350,000	75,000			3,719,455	3,581,955	50	179,000,000

POSTWAR CONSUMPTION OF DISTILLATE FUEL OIL

Since the demand for heating oil constitutes the chief component of that for distillate fuel oil, the outlook for consumption of distillate fuel depends largely upon the outlook for oil-burner installations. This, in turn, depends upon residential building, which, barring the continuation of rent controls, is expected by most authorities to be at a high rate, possibly amounting to as much as 1,000,000 dwelling units per year during the period under review. With this view of the building outlook (a view subscribed to by the writer), burner installations should be high for several years after the war. As shown in Table 6, therefore, burner sales are expected to reach 400,000 units in the second and third postwar years, thereafter dropping to 350,000 units. These estimates compare with a peak of 330,000 units manufactured in 1941. Although oil-burner scrappage is estimated at approximately twice the prewar average, the large estimated production figures are sufficient to increase the average number of burners in use from 2,270,000 in 1941 to 3,580,000 in 1950. It is expected that more than half of the burners converted to coal during the war will be reconverted to oil after the war is over, but this process does not account for a significant portion of the large increase in burners in use.

For the early postwar years, the consumption per burner has been held at the prewar average (assuming normal weather) of 54 bbl. per burner per year, but during the last two years of the period consumption per unit has been decreased slightly, on the assumption that greater efficiency of postwar burners will materialize. These two sets of estimates provide the heating-oil estimates shown in Table 7, which indicate that this category of demand for

distillate fuel oil will amount to 179,000,000 bbl. in 1950 compared with 121,000,000 bbl. in 1941, representing an increase of 48 per cent during the period.

Estimates of consumption of diesel fuel oil reflect the abnormal expansion during the war (and the inevitable contraction as we return to peacetime conditions) plus the continued growth in the use of this fuel by trucks and railroads after the war.

TABLE 7.—*Estimated Demand for Distillate Fuel Oil in the United States*
1000 BARRELS OF 42 GALLONS EACH

Year	Domestic				Export	Total
	Heating	Diesel	All Other	Total Domestic		
1941	120,908	27,351	25,775	174,034	15,741	189,775
1942	121,506					205,473
1943	106,000					220,200
1944	106,000					230,000
1945	110,000					210,000
1946	131,000	33,000	26,000	190,000	10,000	200,000
1947	145,000	35,500	27,500	208,000	8,000	216,000
1948	162,000	37,500	28,500	228,000	6,000	234,000
1949	172,000	40,500	29,500	242,000	4,000	246,000
1950	179,000	42,500	30,500	252,000	2,000	254,000

Demand for this product is expected to be 33,000,000 bbl. in the first postwar year (21 per cent greater than in 1941) and 42,500,000 bbl. in 1950 (55 per cent greater than in 1941, the peak prewar year).

Other uses are expected to increase moderately over the period, rising to 30,500,000 bbl. by 1950.

In line with the writer's general pessimism regarding exports, exports of distillate fuel oil are expected to decline constantly, so that by 1950 they will amount to only 2,000,000 barrels.

POSTWAR CONSUMPTION OF KEROSINE

The prewar growth in demand for kerosine was largely the result of its use in space heaters. The proportion used for heating purposes is not available, however, chiefly because accurate statistics on the number of consuming units are not available. Also, some of the range oil used in space heaters was sold as distillate fuel oil and not as kerosine. For these reasons, any estimate of the proportion of total kerosine demand used for heating purposes is hazardous, to say the least, but it is the writer's guess that approximately 50 per cent was so used. The remaining 50 per cent was used for cooking, for illumination, and as tractor fuel, although the last named category was a relatively small part of the total.

TABLE 8.—*Estimated Demand for Kerosine in the United States*
1000 BARRELS OF 42 GALLONS EACH

Year	Domestic Demand	Exports	Total
1941	70,023	2,676	72,699
1942			72,313
1943			73,000
1944			73,000
1945			74,500
1946	72,000	6,400	78,400
1947	74,000	3,700	77,700
1948	76,000	2,600	78,600
1949	78,000	1,100	79,100
1950	80,000	600	80,600

Although the writer believes that the use of kerosine for heating purposes will continue to expand during the period of this forecast, he also believes that consumption for other uses probably will decline in total, chiefly because with the high incomes expected there will be a greater tendency to shift to electricity or gas. For that reason, the estimates of domestic consumption indicate moderate increases over the period, with demand in 1950 amounting to 80,000,000 bbl., or a 14 per cent increase over consumption in 1941.

For the immediate postwar years, exports are shown at high levels relative to the 1941 exports, in order partly to supply areas in Asia and Oceania, which in later years are expected to obtain supplies from the Far East. The exports are almost eliminated by the end of the period, as supplies are made available from more economical sources. The declining exports tend to offset gains in domestic demand during the postwar period, so that only a

small gain is shown in total demand. These estimates are shown in Table 8.

Postwar Consumption of Lubricating Oils

The domestic estimates shown for lubricating oil (Table 9) are calculated figures based upon ratios of consumption of lubricating oil to that of automotive and aviation gasoline and, for industrial oils, a correlation with the F.R.B. index of production at the levels of that index given in Table 1. The ratio used for automotive consumption in the postwar years was 0.02 except for 1946, for which 0.021 was used. Estimates of consumption of aviation oil were based upon a ratio to consumption of aviation gasoline of 0.035 in 1941 and 0.022 in postwar years, the lower figure used in the later years reflecting the most recent data available to the writer.

Table 9.—*Estimated Demand for Lubricating Oil in the United States*
1000 Barrels of 42 Gallons Each

Year	Domestic			Total	Exports	Total Demand
	Automotive	Industrial	Aviation			
1941	12,000	19,000	400	31,400	8,779	40,179
1942						37,329
1943						40,900
1944						45,600
1945						44,800
1946	11,400	16,000	400	27,800	10,000	37,800
1947	13,200	17,200	400	30,800	9,650	40,450
1948	14,200	18,400	400	33,000	9,400	42,400
1949	14,600	19,600	600	34,800	9,200	44,000
1950	15,000	20,200	700	35,900	8,900	44,800

The exports include very small amounts of aviation grades. In total, the estimates of lubricating-oil exports indicate a declining trend, which is consistent with the writer's view that the United States will gradually lose its formerly large export business to foreign refiners as manufacturing facilities are constructed in various parts of the world. The estimates of total demand, therefore, indicate a figure in 1950 of 44,800,000 bbl., which is only 12 per cent greater than in 1941.

Postwar Consumption of Crude Oil and Products

The foregoing predictions are summarized in Table 10, which also includes estimates for miscellaneous products, amounts burned at refineries, and losses, in order to provide estimates of crude and product demand. In addition, an estimate of crude-oil exports is given, which indicates a decline to 20,000,000 bbl. in 1948 (representing amounts that are expected to move over the border into Canada) from the 1941 figure of 32,225,000 bbl. In this case, also, the writer believes that exports from the United States will be partly replaced by petroleum from foreign sources. The large miscellaneous figure is based upon prewar relationships with the total volume of products handled and has been increased during postwar years in line with the larger demands forecast.

Table 11.—*Estimated Total Demand for Crude and Products*

Year	1,000 Bbl.	1,000 Bbl. Daily
1941	1,594,542	4,370
1942	1,559,378	4,270
1943	1,637,800	4,490
1944	1,748,400	4,780
1945	1,655,000	4,530
1946	1,540,700	4,220
1947	1,684,150	4,610
1948	1,772,500	4,840
1949	1,825,100	5,000
1950	1,872,800	5,130

Based upon these forecasts, the domestic demand for crude and products in 1946 is only 3.7 per cent less than in 1941, and in 1950 is 22 per cent greater than in the last prewar year. A sharp increase in demand is shown in 1947 over the previous year, the increase being chiefly attributable to the increase in demand for gasoline. Exports exhibit a steady decline to a figure that in 1950 is less than one half the 1941 rate. The estimates of total demand for crude and products are shown in Table 11.

These estimates indicate a demand in 1946 approximately 12 per cent less than

TABLE 10.—*Estimated Demand for Crude and Products in the United States*
1000 BARRELS OF 42 GALLONS EACH

Year	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Domestic demand:										
Gasoline	670,577					620,000	739,000	794,000	820,000	850,000
Residual fuel oil	383,339					353,000	373,000	394,000	406,000	413,000
Distillate fuel oil	174,034					190,000	208,000	228,000	242,000	252,000
Kerosine	70,023					72,000	74,000	76,000	78,000	80,000
Lubricating oils	31,400					27,800	30,800	33,000	34,800	35,900
Crude oil, misc., and losses	164,142					175,000	180,000	185,000	190,000	195,000
Total	1,493,515					1,437,800	1,604,800	1,710,000	1,770,800	1,825,900
Exports:										
Gasoline	24,076					29,500	20,000	16,500	15,000	12,500
Residual fuel oil	13,828					13,000	10,000	6,000	4,000	2,000
Distillate fuel oil	15,741					10,000	8,000	6,000	4,000	2,000
Kerosine	2,676					6,400	3,700	2,600	1,100	600
Lubricating oils	8,779					10,000	9,650	9,400	9,200	8,900
Crude oil	32,225					30,000	25,000	20,000	20,000	20,000
Miscellaneous	3,702					4,000	3,000	2,000	1,000	900
Total	101,027					102,900	79,350	62,500	54,300	46,900
Total demand:										
Gasoline	694,653	624,092	617,700	700,000	675,000	649,500	759,000	810,500	835,000	862,500
Residual fuel oil	397,167	412,619	468,700	479,800	432,700	366,000	383,000	400,000	410,000	415,000
Distillate fuel oil	189,775	205,473	220,200	230,000	210,000	200,000	216,000	234,000	246,000	254,000
Kerosine	72,699	72,313	73,000	73,000	74,500	78,400	77,700	78,600	79,100	80,600
Lubricating oil	40,179	37,329	40,900	45,600	44,800	37,800	40,450	42,400	44,000	44,800
Crude oil, misc., and losses	200,069	207,552	217,300	220,000	218,000	209,000	208,000	207,000	211,000	215,900
Total demand for crude and products	1,594,542	1,559,378	1,637,800	1,748,400	1,655,000	1,540,700	1,684,150	1,772,500	1,825,100	1,872,800

in 1944, the estimated peak war year, and only 3.4 per cent less than in 1941. Subsequent to 1946, the estimates show consistent annual increases, so that the 1941 demand is exceeded by 1947, and by 1950 it is 17.5 per cent greater than in 1941. On a monthly basis the magnitude of the drop from the peak war demand to the minimum peacetime demand would be greater of course, than the 12 per cent indicated by the annual figures. For example, for November 1943 the writer estimates that total demand was 4,880,000 bbl. per day, which is 100,000 bbl. per day greater than the estimated average for the year 1944.

Conclusion

In closing, the writer wishes to sound a note of caution. Since this paper has been concerned *only* with the *demand* for petroleum products and crude and products and *not* with the *supply* necessary to meet the projected demands, the estimates should not be used as an indication of the pattern of requirements for domestic crude oil. In addition to the crude oil produced in this country, the total supply of petroleum products available to meet requirements includes a substantial amount of natural gasoline and some imports of residual fuel oil and heavy crude. Also, it is generally believed that one important effect of the substantial construction of catalytic cracking plants during the war will be to increase the yields of light products at the expense of the yield of residual fuel oil, thereby making it possible to produce the light product requirements with less crude oil than would be necessary with the older thermal cracking processes. To the extent that these developments are effective, domestic crude-oil requirements will be reduced relative to total product requirements, and imports of residual fuel, or heavy crude, will be increased. It also follows that the drop in domestic crude-oil requirements from the wartime peak to the postwar low should be greater than the drop in demand for crude and products.

Postwar Inventories of Crude Oil and Petroleum Products in the United States

By Albert J. McIntosh*

(New York Meeting, February 1945)

Abstract

With petroleum consumption declining temporarily after V-J day, the oil industry is urged to use this period as a kind of stopgap to rebuild its war-depleted inventories and help cushion the effect of this decline on producers and refiners. Higher inventories should be reestablished, since recent experiences have indicated that, by and large, the present inventories of crude oil are too low even with the tremendous current production available. The following analysis indicates that inventory levels could be built up to about 490,000,000 bbl. by the end of 1947, an increase of about 40,000,000 bbl. over the reported stock estimated for the war's end. If at the end of the war the military have some 20,000,000 bbl. on hand, this inventory will either be resold to the industry or certain demands that have been assumed to be met by industry will be supplied out of these military stocks, which would leave about 20,000,000 bbl. (net) to be built up from current production. For stock rebuilding the industry could use 10,000,000 bbl. of crude plus 10,000,000 bbl. of products, totaling 20,000,000 bbl. If this were spread over a year, this would mean 55,000 bbl. a day. By analyzing the average inventories held in a year with the total quantity of goods handled during the year, the following study and tables indicate how far the inventories should increase in the immediate postwar period.

Introduction

For the period immediately following V-J day, most of the petroleum economists have forecast a considerable decline in the total consumption of petroleum and its products in the United States. This will be caused by the elimination of most of the military demands and the inability of civilians to immediately replace automobiles, burners, etc., and thus increase their requirements to make up for the military decline. When the automobile industry has been back on full production for two or three years, civilians will be able to consume much larger quantities of gasoline. Delay in the manufacture of new oil burners and the time it takes to construct new homes, adds up to the same story for distillate fuels. In reviewing this outlook, the question has arisen whether the petroleum industry should not use this period of lower consumption as a kind of stopgap to rebuild its war-depleted inventories and help cushion the effect on producers and refiners of this sudden drop in requirements. Some persons have indicated that hundreds of thousands of barrels a day could be used for this purpose extending over a year or more. Refineries will be in existence, which could run over 5,000,000 bbl. of crude oil a day and crude-oil production might be running 600,000 to 700,000 bbl. a day above the demands now forecast for the period after V-J day.

Reasons for Making Inventories

In order to plan intelligently for this period, the petroleum industry should determine the needs for the establishment of higher inventories for crude and petroleum products than have been carried during the war. The reasons for trying to make such a determination are as follows:

Manuscript received at the office of the Institute Feb. 21, 1945. Issued as T.P. 1870 in Petroleum Technology, May 1945.

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1. To provide a guide for individual companies as to the probable additional cash which would have to be tied up in these larger inventories.

2. To help refiners estimate the probable rate of operations required and whether they will feel the full impact of the decrease in military demands not offset by increased civilian demand.

3. To help producers and all federal and other regulatory bodies that will want to have a guide for interpreting these demand forecasts in terms of crude-oil production.

4. To try to help the industry evaluate the effect of the military inventories held in the United States and in foreign countries.

The attached analyses Tables 1-8 are based upon V-J day happening on or before Dec. 31, 1946, and the conception that 1947 will be the first complete postwar year.

Inventories, of course, reflect the goods that industry has to carry in order to conduct its business but the changes in them also reflect the differences between supply and demand. They are "the best single criteria of economic operation," as Mr. John Gill quoted in 1931.

Basis for Analysis

If we had available all of the detailed requirements for inventories such as pipe line and tank fill, goods in transit, unfinished or unblended stocks, shipping stocks, etc., we would use these as a basis for analyzing inventories. These are not available. Certain figures have been published from time to time supposedly stating the requirements of finished-product inventories but we believe the only sufficiently detailed study that has been made was that of the Gasoline Inventory Committee during the N.R.A. days. This study was very carefully made over a long period of time and by individual locations, and even then the results as published provided too large an inventory for the industry, which was proved by subsequent events. Various reports have also been published, including one by the writer, attempting to analyze the requirements of crude oils by fields and areas. The writer submitted a report to the Texas Railroad Commission in 1938 showing a requirement of 225 million barrels of refinable crude. To that should be added for comparison with present day conditions, some 5 million barrels of nonrefinable crude in California and a similar quantity for filling new crude pipe lines, including the "Big Inch." This would mean that that report brought up to date would have shown a figure of 235 million barrels.

We find that at the end of March 1945 the industry expects to have on hand 445,000,000 bbl. of crude and products and at the end of the year might have 450,000,000 bbl. In most cases these are minimum stocks necessary to deliver over 5,000,000 bbl. per day of the individual products required at the proper places. During the war these low levels have been under test and we believe they represent what analysts call low "resistance levels." When you think that 450,000,000 bbl. means only 90 days supply from well to distributor or ship—or about 3 months supply, including crude oil and goods in process—that really is not so large when compared with other basic industries covering comparable functions. Below these levels serious operating troubles begin to appear. Crude oil of certain kinds runs short in certain places. Products run out here and there, ships are delayed, tank cars are held up and pipe lines are not filled to capacity. All of these results have appeared from time to time, which gives us a good test of inventory levels that cannot be reduced without trouble. On the other hand, we believe the industry as a whole has been surprised at the low level of inventories that could be reached before the dire results predicted really came about. Not to cast any reflections, because none are intended, but we can re-

member when many persons on the Pacific Coast maintained that 125,000,000 bbl. of inventories were necessary for that area. Experience with much lower inventories indicates that it was not necessary. The East Coast has existed on an average of 48,500,000 bbl. plus military stocks during the last couple of years and carried on a business of 1,700,000 bbl. a day, but of course this cannot be compared with other areas that produce crude and refine more than they consume locally.

We do not see any particular reason why the industry should not have about the same quantity on hand at the end of 1946 as we estimate it will have at the end of 1945, with one exception. After V-E day the demand for residual fuel oil may be somewhat reduced, and if this happens the inventories of residual fuel oil may be considerably higher than forecast at the end of 1945.

In order to try to get some fairly complete ideas of how far the inventories should increase in the immediate postwar period, we have shown on the attached tables all of the past history of these inventories and their related factors. These related factors are the production and interdistrict receipts or interproduct transfers in the various areas. Our method of analysis has been to relate the average inventories held in a year with the total quantity of goods handled during the year and have shown as a memorandum a calculation of the average number of months supply for each of the years under consideration. We believe this is the best guide for forecasts of future requirements. We have disregarded the very low inventories held in many cases during the war period because we do not believe that these form a good guide for the postwar period. The industry should reestablish more easy-going levels of inventories, so that the shortages and disruptions caused by these low inventories would not recur. Another thing that should be taken into consideration would be that when tankers return to supply the East Coast, larger inventories must be maintained because of the large quantity of single deliveries to all locations receiving supplies by tanker versus the quantities delivered when tank cars are used. This is a slight penalty caused by the use of tankers as contrasted with tank cars but it should be recognized. In practically all our forecasts we have allowed a greater number of months supply than in the lowest prewar years, unless some particular condition was known to warrant a lower figure.

The related factors forecast are simply the production rates necessary to supply the total market as forecast and the interdistrict shipments, interproduct transfers and imports that may come about in that period. These were forecast by products for each geographic area.

We believe that recent experiences have indicated that, by and large, the present crude-oil inventories are too low even with the tremendous current production available. Our estimate is that the industry could more conveniently and economically carry on its business if it were able to maintain a crude-oil inventory of about 230,000,000 bbl. Included in this is 35,000,000 bbl. for the Pacific Coast. Some people have indicated that they could get along with less than this, which undoubtedly is true. The 35,000,000 bbl. assumed for 1947 is considerably below any prewar year in either actual figures or months supply. We believe that industry could get along with less, but what we are trying to show on these schedules for crude as well as products are not the minimum inventories that the industry could struggle along with but those inventories that would give a reasonable flexibility to the industry, which would allow some cushioning of the severe drop in demand that has been forecast by many writers to happen immediately after V-J day. Each individual

product has been analyzed in detail and the results are included in the study. Included in gasoline and distillate requirements are fills for the "Little Inch" pipe line not in prewar stocks.

Effect of Military Supplies

As mentioned previously, one offset to this increase in inventories that the industry might carry after the war would be the quantity that might be on hand in possession of the military in the United States and foreign countries at the close of the war. No exact figures, of course, are available for these stocks but reasonably informed guesses can be secured, and on the basis of these we believe the military today has in excess of 20,000,000 bbl. on hand in the United States which quantities are not included in the published inventory figures. These naturally fluctuate from month to month but we think such a figure is reasonably close. By the end of the war the military might have on hand somewhat less if the larger inventories held on the East Coast for prosecution of the European war are liquidated, provided the European war is terminated considerably before the Japanese phase.

Our analysis indicates that inventory levels could be built up to about 490,000,000 bbl. by the end of 1947. Therefore the greatest quantity that the industry should anticipate putting back into inventories is about 40,000,000 bbl. If the military by the end of the war have some 20,000,000 bbl. on hand, this inventory will either be resold to the industry or certain demands that have been assumed to be met by industry will be supplied out of these military stocks, and the industry would have to back up a similar quantity in its own tanks. Therefore it makes little difference what decisions are made regarding this inventory, the economic effect of its existence would be the same. This is also true to some extent for the inventories held by the military in foreign countries. So little is known regarding these quantities or their distribution that the writer has had to eliminate these from consideration in these conclusions. We believe nevertheless that some part of these inventories would affect the situation in the United States.

Finished Products

The final conclusion is that the industry most likely can figure on running about 10,000,000 bbl. more in its refineries in 1947 than the demands would indicate and use these excess runs for inventory rebuilding. This would make the industry inventories of products as follows:

	Barrels
Forecast for 12/31/1945 or 46—total refined products	230,000,000
Estimate of military inventories of finished products	20,000,000 (maximum)
Total inventories, industry and military	250,000,000 (maximum)
Inventory requirements—maximum 1947	260,000,000
Total that can be run and stored as finished products	10,000,000
or	27,500 bbl. per day

In addition to this 10,000,000 bbl. of finished products, which refineries could run for inventory rebuilding, producers most likely could count upon the production of 10,000,000 bbl. for rebuilding crude inventories as such, because the present outlook is that the industry may wind up the war with about 220,000,000 bbl. on hand and our present analysis indicates that the industry could very well rebuild this inventory to 230,000,000 bbl. to help cushion the effect of the reconversion period cutback.

Summary

Summarizing this study, we believe the industry could use 10,000,000 bbl. of

products plus 10,000,000 bbl. of crude, or a total of 20,000,000 bbl. of crude oil and products, for purposes of stock re-building without exceeding proper economic levels and causing waste by excessive losses through leakage or evaporation, not to mention loss on overinvestment and insurance. If this were spread over a year, it would mean 55,000 bbl. a day. If it were assumed that demand for crude oil would drop from 4,700,000 bbl. a day to 4,000,000 bbl. a day after V-J day, producers could count on 4,055,000 bbl. a day as needed for demand and stockbuilding, and refiners, instead of cutting back the whole 700,000 bbl. a day, could figure on a reduction of only 672,500 bbl. a day. Saying it another way, the effect of stock rebuilding on either the producer or refiner would amount to only around 1 per cent. This additional quantity is not much, but it seems to the writer that it is just as important to determine as though the results showed a very large figure. There may be some postwar rebuilding of secondary or consumer inventories, which would cause a demand during that period somewhat above current consumption. How much this would be we have no way of estimating. We believe, however, that the quantities could not be nearly as large as those shown in this analysis of reported inventories.

The industry generally would not want to carry inventories higher than necessary and the public interest should be considered to prevent the resultant waste when aboveground stocks are excessive. It is true, of course, that the relation between aboveground and belowground supply should be taken into consideration but the United States for many years should have sufficient reserves within its own boundaries to make this factor relatively unimportant. Where an industry has to depend upon sources outside of the United States for a large part of its raw material, there is justification and perhaps necessity for a much greater month's supply. This is not the case for petroleum.

The writer in his previous reports included a possible stock build-up figure after V-J day much larger than now submitted. We believe that this has been the experience of those few who have studied the situation. The greater the study, the lower the totals. We have had the benefit of many comments from confreres and with only one exception the comments were that our figures were too high. We revised some of the figures downward, and wish to thank our good friends for their help.

In trying to test our conception of proper postwar inventories, we have looked at prices as a confirmation but not as an aid to original selection. This seemed necessary in view of the reasons for changes in inventories. If supplies are more than demand, inventories naturally increase until corrections take place. During these times, if economic law were fully operating, prices should decline. Contrawise, when inventories are lower than normal, they are a reflection of inadequate supply, and when this happens, prices should be firm. In many instances, this relationship between inventory levels and prices confirmed the choice of the years selected for determining a normal "month's supply." Where this relation did not appear, other conditions probably occurred that led us to ignore those particular years in trying to arrive at conclusions for use in our postwar estimates. For prices, we have shown the calendar year averages as well as the same prices using a six months lag. With these data and all of the past inventories, anyone may arrive at different conclusions. If we have helped in the determination of some sound ideas regarding inventory requirements, we shall have been fully repaid for these efforts.

TABLE 1.—*Inventories of Crude and Products, by Areas in the United States*
THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors			Month's Supply
	3/31	6/30	9/30	12/31	Average	Crude Runs to Stills	Receipts of Finished Prods.	Total	
					EAST COAST DISTRICT				
1937	50,342	57,496	64,324	57,479	57,400	198,080	240,160	438,240	1.572
1938	60,703	61,683	61,847	55,978	60,000	180,606	242,647	423,253	1.701
1939	61,310	66,699	67,227	61,465	64,200	192,381	270,839	463,220	1.663
1940	59,032	73,099	81,659	72,621[a]	71,500	204,465	302,888	507,353	1.691
1941	59,500	65,943	76,571	74,755[b]	69,200	217,046	324,571	541,617	1.533
1942	48,379	44,257	54,682	41,184	47,100	161,442	275,212	436,654	1.294
1943	34,423	40,136	49,820	52,073	44,200	194,219	305,364	499,583	1.062
1944	44,474	51,658	63,276	53,276	53,150	256,990	358,300	615,290	1.037
1945	42,000								
1947	65,700	71,100	80,000	73,200	72,500	216,000	319,000	535,000	1.626
					GULF COAST DISTRICT				
1937	70,178	73,824	77,737	80,958	75,700	332,756	170	332,926	2.729
1938	81,035	84,897	89,588	82,474[c]	84,500	354,809		354,809	2.858
1939	79,268	82,015	79,754	80,739	80,400	382,400		382,400	2.523
1940	82,701	89,292	93,973	94,719	90,000	383,005	1,927	384,932	2.806
1941	96,780	100,187	93,976	98,796[d]	97,400	417,532	1,597	419,129	2.789
1942	106,320	104,282	103,816	107,943	105,500	360,302	2,071	362,373	3.494
1943	105,685	97,321	99,633	107,395	102,400	392,136	2,190	394,326	3.116
1944	108,255	106,269	109,274	111,028	108,700	493,407	1,282	494,689	2.637
1945	108,250								
1947	89,800	88,000	88,900	92,100	89,700	420,000	2,000	422,000	2.551
					INLAND DISTRICTS				
1937	288,526	296,169	296,677	298,616	295,000	449,459	Not Available	449,459	7.876
1938	304,939	287,650	271,828	259,112[e]	281,000	429,266		429,266	7.855
1939	261,502	259,399	228,932	231,579	245,300	465,405	58,000[j]	523,405	5.624
1940	249,650	252,762	252,665	251,948	251,800	505,669	63,000[j]	568,669	5.313
1941	257,791	247,477	237,511	241,285[f]	246,000	561,481	68,928	630,409	4.683
1942	255,637	239,200	227,366	223,154	236,500	582,495	61,319	643,814	4.408
1943	231,218	224,922	221,615	225,638	225,800	579,515	73,846	653,361	4.147
1944	233,424	230,904	224,486	228,030	229,250	619,528	101,884	721,412	3.813
1945	222,050								
1947	224,800	227,200	228,000	227,800	226,900	568,000	70,000	638,000	4.268
					CALIFORNIA				
1937	125,554	124,165	121,804	127,944	125,000	203,145	17,467	220,612	6.799
1938	142,434	149,974	153,324	158,357[g]	151,000	200,334	10,680	211,014	8.587
1939	161,783	160,533	153,661	152,055	157,000	198,564	6,551	205,115	9.185
1940	153,237	151,741	149,162	145,296	149,900	201,023	4,426	205,449	8.755
1941	143,917	138,265	136,778	137,492[h]	139,000	213,133	9,031	222,164	7.508
1942	136,443	127,958	126,731	125,659	129,200	230,164	14,685	244,849	6.332
1943	126,494	121,707	110,301	98,948	114,400	263,868	21,146	285,014	4.817
1944	86,209	84,162	89,454	86,927	86,700	293,657	39,550	333,207	3.122
1945	72,100								
1947	96,700	94,700	94,700	96,700	95,700	250,000	5,000	255,000	4.504
					TOTAL UNITED STATES				
1937	534,600	551,654	560,542	564,997	553,100	1,183,440	29,673	1,213,113	5.471
1938	589,111	584,204	576,587	555,921 567,703[i]	576,500	1,165,015	27,896	1,192,911	5.799
1939	563,863	568,646	529,574	525,838	546,900	1,238,840	25,965	1,264,805	5.189
1940	544,620	566,894	577,459	564,584 563,277[i]	563,200	1,294,162	41,089	1,335,251	5.062
1941	557,988	551,872	544,836	552,328 555,810[i]	551,600	1,409,192	46,536	1,455,728	4.547
1942	546,779	515,697	512,595	497,940	518,300	1,334,103	16,822	1,350,925	4.60
1943	497,820	484,086	481,369	484,054	486,800	1,429,738	3,440	1,433,178	4.0[illegible]
1944	472,362	472,993	486,490	479,261	477,800	1,663,582	3,900	1,667,482	3.438
1945	444,400			450,000					
1947	477,000	481,000	491,600	489,800	484,800	1,454,000	75,000	1,529,000	3.805

[a] New basis 71,314 TB. [b] New basis 77,430 TB. [c] New basis 83,694 TB. [d] New basis 99,311 TB.
[e] New basis 260,114 TB. [f] New basis 241,925 TB. [g] New basis 157,563 TB. [h] New basis 137,759 TB.
[i] New basis. [j] Estimated.

TABLE 2.—*Inventories of Crude Oil, by Areas in the United States (Includes Heavy Crude in California)*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors		Average Prices	
	3/31	6/30	9/30	12/31	Average	Crude Runs, Thous. Bbl. Yearly	Month's Supply	Yearly Dollars per Barrel	Six Months Lag
EAST COAST DISTRICT								East Texas Posted Price	
1937	13,304	15,464	14,782	13,744	14,300	198,080	0.866	$1.31	$1.35
1938	15,547	13,392	12,441	12,682	13,500	180,606	0.897	1.28	1.16
1939	12,595	13,774	11,758	12,717	12,700	192,381	0.792	1.09	1.09
1940	11,926	17,076	14,915	13,885	14,400	204,465	0.845	1.10	1.12
1941	11,640	13,742	14,151	11,652	12,800	217,046	0.708	1.20	1.25
1942	8,310	7,505	7,456	6,619	7,400	161,142	0.551	1.25	1.25
1943	6,984	9,060	8,167	8,227	8,100	194,219	0.501	1.25	1.25
1944	9,504	10,141	10,575	10,800	10,300	256,990	0.481	1.25	
1945	10,800								
1947	15,700	15,700	13,700	13,700	14,700	216,000	0.817		
GULF COAST DISTRICT								Gulf Coast 34° Gr. Posted Price	
1937	32,027	34,200	34,166	32,617	33,300	332,576	1.202	$1.28	$1.29
1938	33,570	34,026	35,386	34,492	34,400	354,809	1.163	1.26	1.20
1939	35,643	33,775	27,123	30,214	31,700	382,400	0.995	1.16	1.16
1940	31,944	34,182	34,655	34,756	33,800	383,005	1.059	1.16	1.20
1941	38,228	40,474	36,659	38,191	38,400	417,532	1.104	1.30	1.36
1942	41,589	40,816	39,841	41,932	41,000	360 302	1.366	1.36	1.36
1943	44,163	45,763	45,445	47,908	45,800	392,136	1.402	1.36	1.36
1944	49,608	46,468	44,242	46,964	46,800	493,407	1.138	1.36	
1945	47,000								
1947	35,000	35,000	35,000	35,000	35,000	420,000	1.000		
INLAND DISTRICTS								Oklahoma 36° Gr. Posted Price	
1937	219,596	226,919	230,368	230,058	226,700	449,639	6.045	$1.21	$1.22
1938	229,429	212,961	201,259	190,720	208,600	429,266	5.831	1.18	1.08
1939	189 482	187 747	159,584	161,749	174,600	465,405	4.502	1.02	1.02
1940	172,037	176 223	178,856	180,373	176,900	505,669	4.198	1.02	1.04
1941	179,742	170,570	161,072	162,065	168,400	561,481	3.599	1.12	1.17
1942	173,945	167,993	158,367	153,568	163,500	582,495	3.368	1.17	1.17
1943	156,584	152,314	150,304	154,417	153,400	579,515	3.176	1.17	1.17
1944	152,071	150,784	145,457	145,115	148,400	619,528	2.874	1.17	
1945	143,400								
1947	145,800	145,800	145,800	145,800	145,800	568,000	3.080		
CALIFORNIA								Kettlemen Hills 35° Gr. Posted Price	
1937	32,969	32,730	30,955	30,407[a]	31,800	203,145	1.878	$1.27	$1.27
1938	47,648	50,350	51,205	53,531[b]	50,700	200,334	3.037	1.27	1.27
1939	55,007	53,011	51,189	48,628	52,000	198,654	3.141	1.27	1.25
1940	49,475	48,507	47,900	47,601	48,400	201,023	2.889	1.22	1.20
1941	49,171	45,620	45,170	45,770	46,400	213,133	2.612	1.21	1.23
1942	50,285	46,564	45,091	43,635	46,400	230,164	2.419	1.23	1.23
1943	44,852	43,528	41,276	39,499	42,300	263,868	1.924	1.23	1.23
1944	31,803	28,356	29,061	26,900	29,000	293,657	1.185	1.23	
1945	23,000								
1947	35,000	35,000	35,000	35,000	35,000	250,000	1.680		
TOTAL UNITED STATES									
1937	297,896	309,313	310,271	306,826[c]	306,100	1,183,440	3.109		
1938	326,194	310,729	300,291	291,425[d]	307,200	1,165,015	3.164		
1939	292,727	288,307	249,654	253,308	271,000	1,238,840	2.625		
1940	265,382	275,988	276,326	276,615	273,500	1,294,162	2.536		
1941	278,781	270,406	257,052	257,678	266,000	1,409,192	2.265		
1942	274,129	262,878	250,755	245,754	258,300	1,334,103	2.323		
1943	252,583	250,665	245,192	250,051	249,600	1,429,738	2.095		
1944	242,986	235,749	229,335	229,779	234,500	1,663,582	1.692		
1945	224,200			220,000					
1947	231,500	231,500	229,500	229,500	230,500	1,454,000	1.902		

[a] New basis 43,919 TB. [b] New basis 52,737 TB.
[c] New basis 320,338 TB. [d] New basis 290,631 TB.

TABLE 3.—*Inventories of Total Refined Products, by Areas in the United States*
THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors			Month's Supply
	3/31	6/30	9/30	12/31	Average	Refinery Output	Receipts Incl. Transfers from Crude	Total	
					EAST COAST DISTRICT				
1937	37,038	42,032	49,542	43,735	43,100	207,878	240,160	448,038	1.154
1938	45,156	48,291	49,406	43,296	46,500	188,866	242,647	431,513	1.293
				53,650[a]					
1939	48,715	52,925	55,469	48,748	51,500	202,963	270,839	473,802	1.304
1940	47,106	56,023	66,744	58,736[b]	57,100	211,564	302,888	514 452	1.332
1941	47,860	52,201	62,420	63,103[c]	56,400	219,019	324,571	543,590	1.245
1942	40,069	36,752	47,226	34,565	39,700	170,720	275,212	445,932	1.068
1943	27,439	31,076	41,653	43,846	36,100	199,488	305,364	504,852	0.858
1944	34,970	41,517	52,701	42,476	42,850	262,756	358,300	621,056	0.828
1945	31,200								
1947	50,000	55,400	66,300	59,500	57,800	222,000	319,000	541,000	1.282
					GULF COAST DISTRICT				
1937	38,151	39,624	43,571	48,341	42,400	339,873	170	340,043	1.496
1938	47,465	50,871	54,202	47,982	50,100	361,209		361,209	1.664
				49,202[a]					
1939	43,625	48,240	52,631	50,525	48,700	393,151		393,151	1.486
1940	50,757	55,110	59,318	59,963	56,200	391,102	1,927	393,029	1.716
1941	58,552	59,713	57,317	60,605[d]	59,000	430,990	1,597	432,587	1.637
1942	64,731	63,466	63,975	66,011	64,500	375,519	2,071	377,590	2.050
1943	61,522	51,558	54,188	59,487	56,600	409,471	2,190	411,661	1.650
1944	58,647	59,801	65,032	64,064	61,900	515,241	1,282	516,523	1.438
1945	61,250								
1947	54,800	53,000	53,900	57,100	54,700	436,000	2,000	438,000	1.499
					INLAND DISTRICTS				
1937	68,930	69,250	66,309	68,558	68,300	466,212	Not Available	466,212	1.758
1938	75,510	74,689	70,569	68,392	72,400	447,787		447,787	1.940
				69,394[a]					
1939	72,020	71,652	69,348	69,830	70,700	479,947	58,000(Est)	537,947	1.577
1940	77,613	76,539	73,809	71,575	74,900	522,145	63,000(Est)	585,145	1.536
1941	78,049	76,907	76,439	79,220[e]	77,600	581,994	68,928	650,922	1.431
1942	81,692	71,207	68,999	69,586	73,000	602,277	61,319	663,596	1.320
1943	74,634	72,608	71,311	71,221	72,400	600,427	73,846	674,273	1.288
1944	81,353	80,120	79,029	82,915	80,850	642,439	101,884	744,323	1.303
1945	78,650								
1947	79,000	81,400	82,200	82,000	81,100	588,000	70,000	658,000	1.479
					CALIFORNIA				
1937	92,585	91,435	90,849	97,537[f]	93,200	216,917	17,467	234,384	4.772
1938	94,786	99,622	102,119	104,826	100,300	213,260	10,680	223,940	5.375
1939	106,776	107,522	102,472	103,427	105,000	213,555	6,551	220,106	5.725
1940	103,762	103,234	101,262	97,695	101,500	211,845	4,426	216,271	5.632
1941	94,746	92,645	91,608	91,722[g]	92,600	226,999	9,031	236,030	4.708
1942	86,158	81,394	81,640	82,024	82,800	243,866	14,685	258,551	3.843
1943	81,642	78,179	69,025	59,449	72,100	277,944	21,146	299,090	2.893
1944	54,406	55,806	60,393	60,027	57,700	308,324	39,550	347,874	1.990
1945	49,100								
1947	61,700	59,700	59,700	61,700	60,700	265,000	5,000	270,000	2.698
					TOTAL UNITED STATES				
1937	236,704	242,341	250,271	258,171[h]	247,000	1,230,880	45,633	1,276,513	2.322
1938	262,917	273,473	276,296	264,496	269,300	1,211,122	38,221	1,249,343	2.587
				277,071[a]					
1939	271,136	280,339	279,920	272,530	275,900	1,289,616	38,098	1,327,714	2.494
1940	279,238	290,906	301,133	287,969	289,700	1,336,656	51,353	1,388,009	2.505
				286,662[a]					
1941	279,207	281,466	287,784	294,650	285,600	1,459,002	62,018	1,521,020	2.253
				298,747[a]					
1942	272,650	252,819	261,840	252,186	260,000	1,392,382	38,469	1,430,851	2.181
1943	245,237	233,421	236,177	234,003	237,200	1,487,330	32,248	1,519,578	1.873
1944	229,376	237,244	257,155	249,482	243,300	1,728,760	36,800	1,765,560	1.654
1945	220,200			230,000					
1947	245,500	249,500	262,100	260,300	254,300	1,511,000	88,000	1,599,000	1.908

[a] New basis. [b] New basis 57,429 TB. [c] New basis 65,778 TB. [d] New basis 61,220 TB.
[e] New basis 79,860 TB. [f] New basis 84,025 TB. [g] New basis 91,989 TB. [h] New basis 244,659 TB.

TABLE 4.—*Inventories of Motor Fuel (Finished and Unfinished), by Areas in the United States*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors			Months' Supply	Average Prices	
	3/31	6/30	9/30	12/31	Average	Refinery Output Incl. Natural Blended	Receipts	Total		Yearly Cents per Gallon	Six Months Lag
EAST COAST DISTRICT										N. Y. Harbor[a]	
1937	18,757	19,442	18,790	18,754	18,900	81,096	108,415	189,511	1.197	7.28¢	7.06¢
1938	23,249	22,562	19,160	17,597	20,600	73,537	108,080	181,617	1.361	6.47	6.13
1939	22,639	21,755	18,653	18,868	20,500	78,897	119,345	198,242	1.241	6.19	6.36
1940	22,472	22,754	20,536	18,622	21,100	77,344	123,205	200,549	1.263	5.81	5.78
1941	20,897	22,614	19,112	21,183[b]	21,000	85,379	135,643	221,022	1.140	7.17	8.27
1942	16,908	14,436	13,299	10,936	13,900	61,135	106,500	167,635	0.995	9.21	9.47
1943	10,503	10,485	9,700	11,906	10,700	68,436	118,000	186,436	0.689	9.20	9.20
1944	11,635	11,606	11,654	12,237	11,800	89,951	172,700	262,651	0.539	9.16	
1945	11,600										
1947	20,400	20,400	18,600	18,600	19,500	83,000	111,000	194,000	1.206		
GULF COAST DISTRICT										Gulf Coast[c]	
1937	13,738	11,618	10,447	15,093	12,700	144,129		144,129	1.057	6.23¢	5.91¢
1938	17,707	13,967	12,885	13,273	14,500	156,869		156,869	1.109	5.38	5.08
1939	14,472	14,062	13,427	17,376	14,800	172,178		172,178	1.032	5.33	5.42
1940	22,390	20,660	16,592	17,374	19,200	161,127		161,127	1.430	4.57	4.32
1941	20,742	16,859	14,984	19,134[d]	17,900	189,469		189,469	1.134	5.46	5.87
1942	26,733	23,303	21,514	21,169	23,100	151,363		151,363	1.831	5.48	5.56
1943	25,047	16,134	15,623	17,257	18,500	156,014		156,014	1.423	5.75	5.75
1944	20,005	18,947	18,356	19,978	19,300	211,414		211,414	1.095	5.71	
1945	22,400										
1947	17,900	14,900	13,900	16,900	15,900	178,000		178,000	1.072		
INLAND DISTRICTS										Group 3[e]	
1937	33,748	30,075	23,679	28,372	29,000	253,949	Not Available	253,949	1.370	5.80¢	5.41¢
1938	34,398	29,724	24,246	26,267	28,700	248,078		248,078	1.388	5.04	4.81
1939	32,484	29,028	24,283	29,468	28,800	265,652	35,000[f]	300,652	1.150	4.89	4.88
1940	39,776	33,106	28,556	31,774	33,300	282,019	40,000[f]	322,019	1.241	4.61	4.74
1941	39,951	34,230	30,864	36,789	35,400	310,528	46,720	357,248	1.189	5.45	5.84
1942	45,961	33,106	27,220	29,690	34,000	289,225	40,515	329,740	1.237	5.76	5.86
1943	37,693	30,421	27,927	31,396	31,800	276,192	45,625	321,817	1.186	5.92	5.98
1944	40,183	36,266	32,637	38,645	36,900	311,758	61,522	373,280	1.186	5.96	
1945	38,300										
1947	40,800	35,700	31,800	35,700	36,000	295,000	45,000	340,000	1.271		
CALIFORNIA										California	
1937	15,408	14,148	12,464	14,771	14,200	79,967		79,967	2.131	5.42¢	5.58¢
1938	16,923	14,278	12,795	14,543	14,600	77,528		77,528	2.260	5.06	4.58
1939	17,526	15,443	14,629	17,153	16,100	79,774		79,774	2.422	4.62	5.18
										5.01[g]	4.94[g]
1940	19,072	17,049	16,223	16,639	17,200	76,885		76,885	2.685	4.55	4.33
1941	17,116	16,057	15,003	16,992	16,300	85,734		85,734	2.281	4.56	4.76
1942	17,242	16,672	16,113	18,331	17,100	85,248		85,248	2.407	4.73	4.76
1943	20,871	20,590	15,969	14,768	18,100	91,783		91,783	2.366	4.76	4.75
1944	15,424	15,165	14,339	15,757	15,200	109,681		109,681	1.663	4.75	
1945	12,600										
1947	17,700	15,700	15,700	17,700	16,700	100,000		100,000	2.004		
TOTAL UNITED STATES											
1937	81,651	75,283	65,380	76,990	74,800	559,141	144	559,285	1.605		
1938	92,277	80,531	69,086	71,680	78,400	556,012	79	556,091	1.692		
1939	87,121	80,288	70,992	82,865	80,200	596,501	47	596,548	1.613		
1940	103,710	93,569	81,907	84,409	90,800	597,375	97	597,472	1.824		
1941	98,706	89,760	79,963	94,098[h]	90,600	671,110	335	671,445	1.619		
1942	106,844	87,517	78,146	80,126	88,100	586,971	99	587,070	1.801		
1943	94,114	77,630	69,219	75,327	79,100	592,425	197	592,622	1.602		
1944	87,247	81,984	76,986	86,617	83,200	722,804		722,804	1.381		
1945	84,900										
1947	96,800	86,700	80,000	88,900	88,100	656,000		656,000	1.612		

[a] 1937–1938 65 and above octane (low); 1939, 68 octane; 1940, 68-70 octane (low); 1941–43, 72-74 octane (low)
[b] New basis 20,618 TB.
[c] 1937–1938 65 and above octane; 1939–40, 68-70 octane; 1941–1943, 72-74 octane (low).
[d] New basis 19,445 TB. [e] All years, 68-70 Octane Chicago Journal of Commerce (low).
[f] Estimated. [g] New basis. [h] New basis 93,844 TB.

TABLE 5.—*Inventories of Kerosine, by Areas in the United States*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors			Month's Supply	Average Prices	
	3/31	6/30	9/30	12/31	Average	Refinery Output	Receipts	Total		Yearly Cents per Gallon	Six Months Lag
						EAST COAST DISTRICT				N. Y. Harbor	
1937	1,117	1,739	2,273	1,512	1,700	11,024	18,806	29,830	0.684	5.89¢[b]	5.94¢
1938	925	1,624	2,456	1,356	1,600	9,208	20,265	29,473	0.651	5.14[b]	4.60
1939	841	1,453	2,248	1,318	1,500	9,120	22,795	31,915	0.564	4.62[b]	5.20
1940	619	1,477	2,866	2,428	1,800	11,447	27,560	39,007	0.554	5.36[b]	5.05
1941	1,146	1,304	3,220	2,489	2,000	9,189	25,616	34,805	0.690	5.16[b]	5.40
1941	4,076[a]	3,984[a]	7,308[a]	6,561[a]	5,400[a]				1.862		
1942	2,456	2,389	4,732	2,853	3,100	7,929	23,360	31,289	1.192	6.27[b]	6.98
1943	1,149	2,168	3,980	3,062	2,600	7,561	28,835	36,396	0.857	7.02[b]	7.10
1944	2,000	3,595	6,142	4,473	4,050	9,523	28,400	37,923	1.282	7.10[b]	
1945	1,500										
1947	2,500	3,300	6,000	3,400	3,800	10,000	25,000	35,000	1.305		
						GULF COAST DISTRICT				Gulf Coast	
1937	1,720	2,677	3,799	2,917	2,800	26,278		26,278	1.279	5.01¢[d]	4.81¢
1938	2,363	4,348	4,587	3,249	3,600	28,394		28,394	1.522	4.22[d]	3.80
1939	2,138	3,231	3,969	2,690	3,000	30,122		30,122	1.195	3.87[d]	4.20
1940	915	2,219	3,621	3,800	2,600	32,061		32,061	0.973	4.13[d]	3.66
1941	2,746	4,649	4,042	3,462[c]	3,700	31,751		31,751	1.398	3.57[d]	3.84
1942	2,737	3,465	3,444	3,746	3,300	22,583		22,583	1.753	3.90[d]	3.94
1943	1,322	2,446	2,331	3,942	2,500	28,363		28,363	1.058	4.08[d]	4.13
1944	1,811	2,416	3,397	2,032	2,400	33,000		33,000	0.873	4.125[d]	
1945	1,500										
1947	2,100	3,200	3,300	3,400	3,000	32,000		32,000	1.125		
						INLAND DISTRICTS				Group 3	
1937	1,715	1,660	2,059	1,781	1,800	22,952	Not	22,952	0.941	4.02¢[d]	4.03¢
1938	1,837	2,039	2,259	2,089	2,100	22,759	Available	22,759	1.107	3.89[d]	3.62
1939	1,656	2,173	2,658	2,510	2,300	24,625	2,000[f]	26,625	1.037	3.47[d]	3.62
1940	1,484	2,102	2,680	2,158	2,100	27,052	2,000[f]	29,052	0.867	3.86[d]	4.03
1941	1,861	2,514	3,394	2,721[e]	2,600	29,489	1,825	31,314	0.996	4.28[d]	4.38
1942	1,986	2,769	3,380	2,940	2,800	34,599	1,825	36,424	0.922	4.38[d]	4.38
1943	1,885	3,038	3,977	1,697	2,700	32,945	3,285	36,230	0.894	4.38[d]	4.38
1944	2,271	3,354	4,679	4,155	3,650	33,394	4,200	37,594	1.165	4.38[d]	
1945	2,900										
1947	1,700	2,800	3,500	3,200	2,800	32,000	3,000	35,000	0.960		
						CALIFORNIA					
1937	844	705	708	873	800	5,054		5,054	1.900	4.01¢	4.41¢[g]
1938	968	1,191	1,195	1,105	1,100	4,219		4,219	3.125	4.14	3.69[g]
1939	970	1,092	1,077	1,058	1,100	4,654		4,654	2.835	4.09	3.68[g]
1940	1,096	1,012	1,087	1,126	1,100	3,322		3,322	3.971	3.6	3.85[h]
1941	971	1,142	1,006	927	1,000	2,157		2,157	5.556	3.63	3.57[h]
1942	721	874	807	525	800	2,363		2,363	4.061	3.50	3.37[h]
1943	512	585	622	658	600	3,401		3 401	2.120	3.43	3.65[h]
1944	485	460	430	491	500	2,614		2,614	2.295	3.18	3.18[h]
1945	300										
1947	1,000	1,000	1,000	1,000	1,000	5,000		5,000	2.400		
						TOTAL UNITED STATES					
1937	5,396	6,781	8,839	7,083	7,100	65,308		65,308	1.305		
1938	6,093	9,202	10,497	7,799	8,400	64,580		64,580	1.561		
1939	5,605	7,949	9,952	7,576	7,000	68,521		68,521	1.384		
1940	4,114	6,810	10,254	9,512	7,600	73,882	204	74,086	1.231		
1941	6,724	9,609	11,662	9,599 14,515[a]	9,200	72,586	191	72,777	1.533		
1942	7,900	9,497	12,363	10,064	10,000	67,474	418	67,892	1.768		
1943	4,868	8,237	10,910	9,359	8,400	72,270	375	72,645	1.388		
1944	6,567	9,825	14,648	11,151	10,600	78,531		78,531	1.620		
1945	6,200										
1947	7,300	10,300	13,800	11,000	10,600	79,000		79,000	1.610		

[a] New basis includes terminals. [b] W.W. low. [c] New basis 3,666 TB. [d] 41-3 W.W. (low).
[e] New basis 3,361 TB. [f] Estimated. [g] Old basis.
[h] New basis prices. Old basis price 1940–1941, 3.77¢.

TABLE 6.—*Inventories of Distillate Fuel Oils, by Areas in the United States*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand: 3/31	6/30	9/30	12/31	Average	Related Factors: Refinery Output	Receipts Incl. Transfers from Crude	Total	Month's Supply	Average Prices: Yearly Cents per Gallon	Six Months Lag
EAST COAST DISTRICT										N. Y. Harbor No. 2 Fuel	
1937	2,885	4,048	7,262	5,090	4,800	30,020	28,194	58,214	0.989	4.97¢	4.89¢
1938	3,089	5,075	7,222	5,821; 12,472[a]	5,300	28,559	29,508	58,067	1.095	4.36	4.02
1939	7,363	9,281	13,094	10,381	10,000	30,638	35,334	65,972	1.819	4.10	4.71
1940	5,683	10,694	18,526	15,922[b]	12,700	39,976	48,188	88,164	1.729	4.74	4.45
1941	7,794	10,773	19,272	18,631[c]	14,100	40,827	47,719	88,546	1.911	4.84	5.31
1942	6,347	5,008	11,247	8,415	7,700	31,132	53,399	84,531	1.093	6.22	6.82
1943	3,502	3,748	8,408	12,293	7,000	38,077	68,440	106,517	0.789	6.70	6.70
1944	5,198	9,386	12,542	9,638	9,200	46,762	64,200	110,962	0.995		
1945	3,500										
1947	7,900	11,000	17,500	14,800	12,800	44,000	47,000	91,000	1.688		
GULF COAST DISTRICT										Gulf Coast No. 2 Fuel	
1937	3,898	5,604	6,556	5,958	5,500	47,185		47,185	1.399	4.16¢	4.05¢
1938	4,125	6,279	7,674	6,505; 7,377[a]	6,200	54,979		54,979	1.353	3.60	3.34
1939	4,662	6,503	7,307	6,543	6,200	62,135		62,135	1.197	3.42	3.76
1940	3,937	6,946	10,787	9,999	7,900	69,351		69,351	1.367	3.58	3.21
1941	7,410	10,281	9,101	9,599	9,100	68,222		68,222	1.601	3.42	3.75
1942	7,639	9,601	12,027	14,007	10,900	70,125		70,125	1.865	3.79	3.75
1943	9,930	7,916	8,724	8,758	8,800	73,983		73,983	1.427	3.75	3.75
1944	7,553	8,629	10,301	8,743	8,800	88,943		88,943	1.187		
1945	6,200										
1947	7,000	7,500	8,500	9,000	8,000	70,000		70,000	1.371		
INLAND DISTRICTS										Group 3 32–6 No. 2 Dark	
1937	3,740	4,940	6,429	4,738	4,900	40,536	Not Available	40,536	1.451	3.36¢	3.34¢
1938	3,999	4,922	6,312	6,077; 6,905[a]	5,300	39,253		39,253	1.620	3.26	3.08
1939	4,338	4,483	7,757	7,132	5,900	38,950	9,000e	47,950	1.477	2.94	3.09
1940	4,164	6,221	8,884	6,954	6,600	45,559	9,000e	54,559	1.452	3.25	3.27
1941	4,541	6,367	10,187	8,983	7,500	52,325	8,030	60,355	1.491	3.37	3.47
1942	4,489	6,406	10,080	10,333	7,800	71,059	5,840	76,899	1.217	3.50	3.50
1943	6,915	9,078	10,474	10,003	9,100	70,575	9,490	80,065	1.364	3.50	3.50
1944	9,480	9,224	10,512	10,425	9,900	72,847	13,662	86,509	1.328		
1945	7,500										
1947	6,700	8,700	12,300	11,300	9,700	64,000	9,000	73,000	1.595		
CALIFORNIA											
1937	6,201	6,065	6,773	6,780	6,500	28,965	19	28,984	2.692	3.25¢	3.30¢
1938	7,669	8,423	9,652	9,470	8,800	28,983	630	29,613	3.566	3.09	2.84
1939	9,536	11,610	9,980	9,662	10,200	30,023	621	30,644	3.994	2.78	2.76[d]
1940	9,302	9,724	10,631	10,065	9,900	28,418	281	28,699	4.139	2.77	2.78
1941	10,060	10,853	12,852	12,713	11,600	27,803	147	27,950	4.981	2.79	2.83
1942	11,730	11,486	12,463	12,185	12,000	24,398	27	24,425	5.897	2.87	2.91
1943	10,788	11,725	12,075	10,674	11,300	28,881	2,265	31,146	4.354	2.89	2.86
1944	7,695	8,003	10,332	10,346	9,100	30,688	8,900	39,588	2.759		
1945	8,600										
1947	8,000	8,000	8,000	8,000	8,000	32,000		32,000	3.000		
TOTAL UNITED STATES											
1937	16,724	20,657	27,020	22,566	21,700	146,706	17	146,723	1.775		
1938	18,882	24,699	30,860	27,873; 36,224[a]	25,600	151,774	623	152,397	2.016		
1939	25,899	31,877	38,138	33,718	32,300	161,746	2,741	164,487	2.356		
1940	23,086	33,585	48,828	42,940; 42,911[a]	37,100	183,304	5,909	189,213	2.353		
1941	29,805	38,274	51,412	49,926; 49,330[a]	42,300	189,177	7,587	196,764	2.580		
1942	30,205	32,501	45,817	44,940	38,400	196,714	5,160	201,874	2.283		
1943	31,135	32,467	39,681	41,728	36,200	211,516	5,080	216,596	2.006		
1944	29,926	35,242	43,687	39,152	37,000	239,240	6,000	245,240	1.810		
1945	25,800										
1947	29,600	35,200	46,300	43,100	38,500	210,000	5,000	215,000	2.149		

[a] New basis. [b] New basis 15,893 TB. [c] New basis 18,035 TB. [d] New basis. Old basis, 1939–1940, 3.01¢.

TABLE 7.—*Inventories of Residual Fuel Oils, by Areas in the United States (Excludes Heavy Crude in California)*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors			Month's Supply	Average Prices	
	3/31	6/30	9/30	12/31	Average	Refinery Output	Receipts Incl. Transfer from Crude	Total		Yearly Dollars per Barrel	Six Months Lag
EAST COAST DISTRICT										N. Y. Harbor-Bunker C	
1937	3,489	4,971	8,346	7,421	6,100	55,274	78,835	134,109	0.546	$1.27	$1.23
1938	6,298	7,078	8,746	7,413 11,116[a]	7,400	50,803	78,390	129,193	0.687	1.04	0.96
1939	6,783	8,837	10,204	7,976	8,400	54,440	83,415	137,855	0.731	1.03	1.27
1940	8,242	9,521	13,057	10,446 9,168[a]	10,300	53,252	95,932	149,184	0.829	1.30	1.22
1941	7,106	6,692	9,665	10,041[b]	8,400	50,113	112,036	162,149	0.622	1.31	1.44
1942	5,105	6,164	8,535	3,613	5,900	45,653	80,665	126,318	0.560	1.61	1.67
1943	3,431	4,723	9,163	6,341	5,900	56,004	74,753	130,757	0.541	1.65	1.65
1944	6,411	6,352	10,873	6,928	7,600	79,677	77,500	157,177	0.580	1.69	
1945	4,000										
1947	7,300	8,800	12,300	10,800	9,800	55,000	123,000	178,000	0.661		
GULF COAST DISTRICT										Gulf Coast	
1937	5,230	5,563	7,845	9,356	7,000	86,435	170	86,605	0.970	$0.91	$0.82
1938	8,127	9,687	11,018	8,140 8,488[a]	9,290	84,417		84,417	1.308	0.69	0.67
1939	6,005	6,539	10,745	7,792	8,300	90,467		90,467	1.101	0.79	0.87
1940	7,156	7,481	9,428	10,792	8,700	89,054	1,927	90,981	1.147	0.84	0.81
1941	9,679	9,465	10,781	10,927 10,740[a]	10,200	97,876	1,597	99,473	1.231	0.83	0.85
1942	9,453	8,978	9,044	7,987	8,900	86,550	2,071	88,621	1.205	0.85	0.85
1943	6,180	6,568	7,705	9,491	7,500	99,318	2,190	101,508	0.887	0.85	0.85
1944	8,749	8,003	10,446	10,811	9,500	113,502	1,282	114,784	0.993	0.90	
1945	9,000										
1947	8,800	8,400	9,200	8,800	8,800	90,000	2,000	92,000	1.148		
INLAND DISTRICTS										14–16 Gr. Group 3	
1937	7,606	8,757	9,619	10,586	9,200	82,655	Not Available	82,655	1.336	$0.81	$0.81
1938	11,556	12,578	13,899	11,438 11,612[a]	12,400	73,629		73,629	2.021	0.76	0.71
1939	10,061	10,433	11,216	9,629	10,300	80,055	5,000[d]	85,055	1.453	0.73	0.80
1940	8,998	9,022	9,632	8,174	8,900	90,222	5,000[d]	95,222	1.122	0.85	0.86
1941	7,964	8,767	9,780	9,028 8,247[a]	8,900	105,967	4,688	110,655	0.965	0.91	0.95
1942	7,080	7,063	7,202	5,952	6,900	122,443	5,474	127,917	0.647	0.95	0.96
1943	5,578	6,895	7,378	6,044	6,500	135,128	6,321	141,449	0.551	0.97	0.97
1944	6,017	7,149	8,115	6,590	7,000	131,707	9,500	141,207	0.595	0.97	
1945	6,100										
1947	6,800	8,200	10,600	10,000	8,900	101,000	6,000	107,000	0.998		
CALIFORNIA											
1937	62,110	61,933	63,197	67,656[c]	63,700	87,700	17,423	105,123	7.271	$0.85	$0.81
1938	60,939	66,347	69,170	70,755	66,800	86,041	10,037	96,078	8.344	0.67	0.60
1939	70,318	70,596	67,898	66,893	68,900	80,982	5,918	86,900	9.514	0.61	0.65
1940	64,955	65,124	62,830	59,892	63,200	83,693	4,070	87,763	8.641	0.64	0.65
1941	56,885	55,024	53,526	53,199	54,600	88,411	8,874	97,285	6.735	0.77	0.85
1942	48,460	44,136	44,483	44,231	45,200	104,255	14,658	118,913	4.561	0.85	0.85
1943	42,091	37,693	33,731	26,608	35,000	126,856	18,881	145,737	2.882	0.90[e]	0.93[e]
1944	24,250	25,145	28,415	26,533	26,100	134,023	29,000	163,023	1.921	0.92[e]	
1945	21,700										
1947	26,300	26,300	26,300	26,300	26,300	100,000	5,000	105,000	3.006		
TOTAL UNITED STATES											
1937	78,435	81,224	89,007	95,019 81,507[a]	86,000	312,064	39,537	351,601	2.935		
1938	86,920	95,690	102,831	97,746 101,971[a]	95,800	294,890	31,102	325,992	3.526		
1939	93,167	98,405	100,063	92,290	95,900	305,944	25,348	331,292	3.474		
1940	89,351	91,148	94,947	89,304 88,026[a]	91,100	316,221	37,065	353,286	3.094		
1941	81,634	79,948	83,752	83,195 82,959[a]	82,100	342,367	50,338	392,705	2.509		
1942	70,098	66,341	69,264	61,783	66,900	358,901	31,724	390,625	2.055		
1943	57,280	55,879	57,977	48,484	54,900	417,306	24,400	441,706	1.491		
1944	45,427	46,649	57,849	50,862	50,200	458,909	30,000	488,909	1.232		
1945	40,800										
1947	49,200	51,700	58,400	55,900	53,800	346,000	83,000	429,000	1.505		

[a] New basis. [b] New basis 9,805 TB. [c] New basis 54,144 TB. [d] Estimated.
[e] New basis. Old basis, 1942–43, $.76.

TABLE 8.—*Inventories of all Other Products,*[a] *by Areas in the United States*

THOUSANDS OF 42-GALLON BARRELS

Year	Inventories on Hand					Related Factors[b]		
	3/31	6/30	9/30	12/31	Average	Refinery Output	Receipts	Total
EAST COAST DISTRICT								
1937	10,790	11,832	12,871	10,958	11,600	30,464	5,910	36,374
1938	11,595	11,952	11,822	11,109	11,600	26,759	6,404	33,163
1939	11,089	11,599	11,270	10,205	11,100	29,868	9,950	39,818
1940	10,090	11,577	11,759	11,318	11,200	29,545	8,003	37,548
1941	10,917	10,818	11,151	10,759	10,900	33,511	3,557	37,068
1942	9,253	8,755	9,413	8,748	9,100	24,871	11,288	36,159
1943	8,854	9,952	10,402	10,244	9,900	29,410	15,336	44,746
1944	9,726	10,578	11,490	9,200	10,200	36,843	15,500	52,343
1945	10,600							
1947	11,900	11,900	11,900	11,900	11,900	30,000	13,000	43,000
GULF COAST DISTRICT								
1937	13,565	14,162	14,924	15,017	14,400	35,846		35,846
1938	15,143	16,590	18,038	16,815	16,600	36,550		36,550
1939	16,348	15,905	17,183	16,124	16,400	38,249		38,249
1940	16,359	17,804	18,890	17,998	17,800	39,509		39,509
1941	17,975	18,459	18,409	17,483	18,100	43,672		43,672
1942	18,169	18,119	17,946	19,102	18,300	44,898		44,898
1943	19,043	18,494	19,805	20,039	19,300	51,793		51,793
1944	20,529	21,806	22,532	22,500	21,900	68,382		68,382
1945	22,150							
1947	19,000	19,000	19,000	19,000	19,000	66,000		66,000
INLAND DISTRICTS								
1937	22,121	23,818	24,523	23,081	23,400	66,120	Not Available	66,120
1938	23,720	25,426	23,855	22,521	23,900	64,068		64,068
1939	23,481	25,535	23,434	21,091	23,400	70,665	7,000[e]	77,665
1940	23,191	26,088	24,057	22,515	24,000	77,293	7,000[e]	84,293
1941	23,732	25,029	22,214	21,699	23,200	83,685	7,665	91,350
1942	22,176	21,863	21,117	20,671	21,500	84,951	7,665	92,616
1943	22,563	23,176	21,555	22,081	22,300	85,587	9,125	94,712
1944	23,402	24,127	23,086	23,100	23,400	92,733	13,000	105,733
1945	23,870							
1947	23,000	26,000	24,000	21,800	23,700	96,000	7,000	103,000
CALIFORNIA								
1937	8,022	8,584	7,707	7,457	8,000	15,231	25	15,256
1938	8,287	9,385	9,307	8,953	9,000	16,489	13	16,502
1939	8,426	8,781	8,888	8,661	8,700	18,122	12	18,134
1940	9,337	10,325	10,491	9,973	10,100	19,527	75	19,602
1941	9,714	9,569	9,221	7,891[c]	9,100	22,894	10	22,904
1942	8,005	8,226	7,774	6,752	7,700	27,602		27,602
1943	7,380	7,586	6,628	6,741	7,100	27,023		27,023
1944	6,552	7,033	6,877	6,900	6,800	31,318	1,650	32,968
1945	5,900							
1947	8,700	8,700	8,700	8,700	8,700	28,000		28,000
TOTAL UNITED STATES								
1937	54,498	58,396	60,025	56,513	57,400	147,661	5,935	153,596
1938	58,745	63,353	63,022	59,398	61,100	143,866	6,417	150,283
1939	59,344	61,820	60,775	56,081	59,600	156,904	9,962	166,866
1940	58,977	65,794	65,197	61,804	63,100	165,874	8,078	173,952
1941	62,338	63,875	60,995	57,832[d]	61,300	183,762	3,567	187,329
1942	57,603	56,963	56,250	55,273	56,600	182,322	1,068	183,390
1943	57,840	59,208	58,390	59,105	58,600	193,813	2,196	196,009
1944	60,209	63,544	63,985	61,700	62,300	229,276	800	230,076
1945	62,500							
1947	62,600	65,600	63,600	61,400	63,300	220,000		220,000

[a] Lubricants, wax, coke, asphalt, road oil, miscellaneous, other unfinished and natural gasoline.
[b] Also crude runs to stills. See Table 1. [c] New basis 8,158 TB. [d] New basis 58,099 TB. [e] Estimated.

Analysis of Decline Curves

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(Houston Meeting, May 1944)

Abstract

Since production curtailment for other than engineering reasons is gradually disappearing, and more and more wells are now producing at capacity and showing declining production rates, it was considered timely to present a brief review of the development of decline-curve analysis during the past three or four decades.

Several of the commoner types of decline curves were discussed in detail and the mathematical relationships between production rate, time, cumulative production and decline percentage for each case were studied.

The well-known loss-ratio method was found to be an extremely valuable tool for statistical analysis and extrapolation of various types of curves. A tentative classification of decline curves, based on their loss ratios, was suggested. Some new graphical methods were introduced to facilitate estimation of the future life and the future production of producing properties where curves are plotted on semilogarithmic paper.

To facilitate graphical extrapolation of hyperbolic-type decline curves, a series of decline charts was proposed, which will make straight-line extrapolation of both rate-time and rate-cumulative curves possible.

Introduction

During the period of severe production curtailment, which is now behind us, production-decline curves lost most of their usefulness and popularity in prorated areas because the production rates of all wells, except those in the stripper class, were constant or almost constant.

While production-decline curves were thus losing in importance for estimating reserves, an increasing reservoir consciousness and a better understanding of reservoir performance developed among petroleum engineers. This fact, together with intelligent interpretation and use of electric logs, core-analysis data, bottom-hole pressure behavior and physical characteristics of reservoir fluids, eliminated a considerable part of the guesswork in previous volumetric methods and put reserve estimates, based on this method, on a sound scientific basis. At the same time, a number of ingenious substitutes were developed for the regular production-decline curve, which made it possible to obtain an independent check on volumetric estimates in appraisal work, even though the production rates were constant.

With the now steadily increasing demand for oil to supply the huge requirements of this global war, proration for reasons other than prevention of underground waste is gradually disappearing. More and more wells are, or will be, producing at capacity or at their optimum rates, as determined by sound engineering practice.

With this trend, the character of producing wells seems to regain, more or less, its "individuality," and the old and familiar decline curve appears to have had a comeback as a valuable tool in the hands of the petroleum engineer. It may be timely, therefore, to retrace the development of decline-curve analysis in the past by presenting a brief chronological review of bulletins and papers published during the past three or four decades, which have

Manuscript received at the office of the Institute May 9, 1944. Issued as T.P. 1758 in Petroleum Technology, September 1944.

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contributed to our present knowledge of this subject. Such a review will, at the same time, serve as a good basis for further analysis of the production-decline curve and its possibilities in this paper.

Development of Decline-curve Analysis

The two basic problems in appraisal work are the determination of a well's most probable future life and the estimate of its future production. Sometimes one or both problems can be solved by volumetric calculations, but sufficient data are not always available to eliminate all guesswork. In those cases, the possibility of extrapolating the trend of some variable characteristic of such a producing well may be of considerable help. The simplest and most readily available variable characteristic of a producing well is its production rate, and the logical way to find an answer to the two problems mentioned above, by extrapolation, is to plot this variable production rate either against time or against cumulative production, extending the curves thus obtained to the economic limit. The point of intersection of the extrapolated curve with the economic limit then indicates the possible future life or the future oil recovery. The basis of such an estimate is the assumption that the future behavior of a well will be governed by whatever trend or mathematical relationship is apparent in its past performance. This assumption puts the extrapolation method on a strictly empirical basis and it must be realized that this may make the results sometimes inferior to the more exact volumetric methods.

The production rate of a capacity well, plotted against time on coordinate paper, generally shows a rapid drop in the beginning, which tends to decrease as time goes on. Changes in method of production, loss in efficiency of lifting equipment, shutdowns for work-over or pulling jobs, usually disrupt the continuity of a production-decline curve, and for mathematical or statistical treatment some preliminary smoothing out is often necessary.

The first and most obvious mathematical approach to a declining production curve is to assume that the production rate at any time is a constant fraction of its rate at a preceding date or, in other words, that the production rates during equal time intervals form a geometric series. This also implies that the production drop over a given constant interval is a fixed fraction or percentage of the preceding production rate. The earliest reference in the literature of this type of decline was made by Arnold and Anderson[1] in 1908. This production drop, as a fraction, usually expressed in per cent per month, is called the decline. A considerable number of the decline curves encountered in appraisal work show this decline percentage to be approximately constant, at least over limited periods. A decline curve showing this characteristic is easy to extrapolate, since the rate-time curve will be a straight line on semilog paper and the rate-cumulative curve on coordinate paper.

The literature between 1915 and 1921 shows a considerable amount of research and study of production curves.[2-6] Much information from various sources was accumulated in the Manual for the Oil and Gas Industry.[7] J. O. Lewis and C. N. Beal, of the Bureau of Mines,[5] recommended the use of the percentage decline curve, which is an empirical rate-time curve, whereby the production rates during successive units of time are expressed as percentages of production during the first unit of time. This makes it possible to bring individual well or lease data to a comparable basis. The results can then be grouped together, either on regular coordinate or log-log paper. From such data on wells in the same area an empirical appraisal curve may be constructed to

[1] References are at the end of the paper.

show the possible ultimate production as a function of the initial production rate.

W. W. Cutler,[8] in 1924, pointed out, after an intensive investigation of a large number of oil-field decline curves, that the assumption of constant percentage decline and a straight-line relationship on semilog paper generally gave results that were too conservative in the final stage. In his opinion, a better and more reliable straight-line relationship could be obtained on log-log paper, although some horizontal shifting usually was necessary. This implied that the decline curves showing such characteristics were of the hyperbolic rather than the exponential or geometric type. He also recommended the use of the family decline curve, either graphically constructed or statistically determined, which is a representative average decline curve for a given area based on a combination of the actual rate-time data from a number of wells in the area.

C. S. Larkey,[9] in 1925, showed how the method of least squares could be applied successfully to decline curves belonging to both the exponential and the hyperbolic types. He also demonstrated that the application of this well-known statistical method makes a strict mathematical extrapolation of a given decline trend possible.

H. M. Roeser,[10] in 1925, showed that equally reliable results can be obtained when, instead of the rigorous method of least squares, a somewhat simpler method of trial and error to determine the necessary constants is followed. He illustrated his method with examples of both the exponential and the hyperbolic types of decline curves. In his paper was also the first reference to the mathematical relationship between cumulative and time for hyperbolic type of decline.

C. E. Van Orstrand,[11] in 1925, investigated the empirical relationship of production curves representing the output of certain minerals by states or nations. Such a curve will rise from zero value at the time of first production to a maximum and then slowly decline, presumably to zero value. The possibilities of various mathematical relationships and different methods of curve fitting are described in this paper. The best results were obtained with a curve of the type:

$$P = At^m e^{-Bt}$$

R. H. Johnson and A. L. Bollens,[12] in 1927, introduced a novel statistical method for extrapolation of oil-well decline curves. With their so-called "loss-ratio method," the production rates are tabulated for equal time intervals, then the drop in production is listed in a second column and the ratio of the two, or "loss ratio," is listed in a third. A curve to be investigated with this method usually shows, after proper smoothing out, either a constant loss ratio or a constancy in the differences of successive loss ratios. Sometimes it may be necessary to take these differences two or three times before constancy is reached, and often additional smoothing out of the data is required. This procedure furnishes an easy and convenient method for extrapolation. It is only necessary to continue the column with the constant figures in the same manner and then work backward to the production-rate column.

H. N. Marsh,[13] in 1928, introduced the rate-cumulative curve plotted on coordinate paper and pointed out that this relationship generally appears to be or approaches a straight line. Although this is only mathematically exact for decline curves of the exponential type, as will be shown later, it was pointed out in his paper that the errors in estimating ultimate recovery with this method in most other cases were generally small or negligible. A distinct advantage of this type of curve is its simplicity in appraising

the effect of different methods of production control on the same well.

R. E. Allen,[14] in 1931, mentioned four types of decline and classified them according to a simple mathematical relationship. The decline types were:

1. Arithmetic, or constant decrement decline.

2. Geometric, constant rate or exponential decline

3. Harmonic, or isothermal decline.

4. Basic, or fractional power decline.

Type 1 is of little practical value for production-decline curves. Type 2 is the well-known straight-line relationship on semilog paper, and type 3 is the special case of hyperbolic decline where the decline is proportional to the production rate. It was not possible to reconcile the equation given for the type 4 decline, as the nominator and the denominator were of the same order, indicating a possible misprint.

S. J. Pirson,[15] in 1935, investigated the mathematical basis of the loss-ratio method and arrived at the rate-time relationships for production-decline curves having a constant loss ratio, constant first differences and constant second differences. Those of the first type appeared to be identical with the simple exponential or constant percentage decline curves, which straighten out on semilog paper; those of the second type were the hyperbolic type of decline curves, which can be straightened on log-log paper and those of the third type appeared to have such complicated mathematical equations as to be unsuitable for practical purposes.

During the period of production curtailment, interest centered upon suitable curves for reserve estimates that did not require the usually constant or almost constant actual rate of production.

H. E. Gross,[16] in 1938, showed the advantages of substituting oil percentage in gross fluid for the production rate in the Marsh rate-cumulative curve. This method, originated by A. F. van Everdingen in Houston, proved particularly valuable for prorated Gulf Coast water-drive production.

For depletion-type or gas-drive-type pools without water encroachment, however, a parameter other than oil or water percentage had to be found to replace the production rate.

W. W. Cutler and H. R. Johnson,[17] in 1940, showed how potential tests, taken periodically on prorated wells (or calculated from bottom-hole pressure and productivity-index data) can be used to reconstruct or calculate the production-decline curve, which the well would have followed if it had been permitted to produce at capacity.

H. C. Miller,[18] of the Bureau of Mines, introduced in 1942 the pressure-drop cumulative relationship on log-log paper and showed how changes in reservoir performance may be detected by abrupt changes in the slope of such a curve.

C. H. Rankin,[19] in 1943, showed how the bottom-hole pressure can sometimes be used to advantage as a substitute for the rate of production of the rate-cumulative curve on prorated leases. Apparently, this method applies only in pools where water drive is absent or negligible and where productivity indexes are constant.

In the Oklahoma City field, which is well known as a typical example of gravity drainage, a plot of fluid level against the cumulative production has been used successfully to estimate the reserves of wells with constant production rates.

P. J. Jones,[21] in 1942, suggested for wells declining at variable rates an approximation whereby the decline-time relationship follows a straight line on log-log paper. This corresponds to an equation:

$$\log D = \log D_0 - m \log t$$

in which D_o designates the initial decline and m is a positive constant. Integration

of this relationship will lead to a rate-time equation of the general form:

$$P = P_o e^{\frac{D_o t^{1-m}}{100(m-1)}}$$

It may be noted that this relationship will not straighten out on semilog or log-log paper, but shows the interesting characteristic of straightening out when the log-log of the production rate is plotted against the log of the time.

F. K. Beach,[20] in 1943, showed, with examples from the Turner Valley field, Canada, how cumulative-time curves sometimes can be extrapolated as straight lines in their last stage by plotting the antilog of the cumulative production against time. Such a straight-line relationship is mathematically correct only for the case of harmonic decline, where the decline itself is proportional to the production rate, as will be discussed later.

Reservoir Characteristics and Decline Curves

In order to analyze what influence certain reservoir characteristics may have on the type of decline curves, it was first assumed that we are dealing with the idealized case of a reservoir, where water drive is absent and where the pressure is proportional to the amount of remaining oil. It was further assumed that the productivity indexes of the wells are constant throughout their life, so that the production rates are always proportional to the reservoir pressure.

In such a hypothetical case, the relationship between cumulative oil produced and pressure would have to be linear and, consequently, also the relationship between production rate and cumulative production.

This linear relationship between rate and cumulative is typical of exponential or semilog decline, as will be shown later (Eq. 4), and simple differentiation will lead to the basic equation for this type of decline in Eq. 1.

In most actual pools, however, the aforementioned idealized conditions do not occur. Pressures usually are not proportional to the remaining oil, but seem to decline at a gradually slower rate as the amount of remaining oil diminishes. At the same time the productivity indexes are generally not constant, but show a tendency to decline as the reservoir is being depleted and the gas-oil ratios increase. The combined result of these two tendencies is a rate-cumulative relationship, which, instead of being a straight line on coordinate paper, shows up as a gentle curve, convex toward the origin.

If the curvature is very pronounced, the curve can sometimes be represented by an exponential equation and the rate-cumulative relationship straightened out on semilog paper. This type is called harmonic decline, and its equation is identical with Eq. 14, derived on page 12. By differentiation, it can be shown that in this case the decline percentage is directly proportional to the production rate.

When the curvature of the rate-cumulative relationship is not pronounced enough to straighten out on semilog paper, it can usually be represented as a straight line on log-log paper after some shifting. This identifies it as a hyperbola and it can be shown that it will fit Eq. 13 (p. 12) for the general case of hyperbolic or log-log decline.

From this general discussion, it is evident that the hyperbolic type of decline curve should be the most common and that harmonic decline is a special case, which occurs less frequently.

The exponential or semilog decline, however, although less accurate, is so much simpler to handle than the other two that it is still quite popular for quick appraisals and approximate estimates; particularly since a large number of decline curves actually show an apparent constant

decline over limited intervals. The decline percentage in such calculations is then usually taken somewhat lower than the actually observed value in order to evaluate the possibility of a smaller decline in the final stage.

Exponential Decline

Exponential decline, which is also called "geometric," "semilog" or "constant percentage" decline, is characterized by the fact that the drop in production rate per unit of time is proportional to the production rate.

Statistical Analysis and Extrapolation

The simplest method to recognize exponential decline by statistical means is the loss-ratio procedure.[12] With this method the production rates P at equal time intervals are tabulated in one column, the production drop per unit of time, ΔP in a second column and the ratio of the two (a = loss ratio) in a third. If this loss ratio is constant or nearly constant, the curve can be assumed to be of the exponential type. The mathematical basis for this will be discussed hereafter.

It will often be found, if time intervals of one month are used and when the decline percentage is small, that the general trend is disturbed considerably by irregularities in the monthly figures, and in such cases it is better to take the production rates further apart. As an example, Table 1 shows the data from a lease in the Cutbank field, Montana, where the monthly production rates are taken at six-month intervals. Since the loss ratio is defined as the production rate per unit of time divided by the first derivative of the rate-time curve, it is necessary in this case to introduce a factor 6 in the last column to correct the drop in production rate during the six months interval back to a monthly basis. The loss ratios in the fifth column of the table appear to be approximately constant. The average value over the period from July 1940 to January 1944 is 86.8 and this value was used to extrapolate the production rate to January 1947 in the lower half of the tabulation. The procedure

Table 1.—*Loss Ratio on a Lease in the Cutbank Field, Montana*
(Typical Case of Exponential Decline)

Month	Year	Monthly Production Rate, P	Loss in Production Rate during 6 Months Interval, ΔP	Loss Ratio (on Monthly Basis), $a = 6\frac{P}{\Delta P}$
July......	1940	460		
January..	1941	431	−29	−89.2
July......	1941	403	−28	−86.4
January..	1942	377	−26	−87.0
July......	1942	352	−25	−84.5
January..	1943	330	−22	−90.0
July......	1943	309	−21	−88.3
January..	1944	288	−21	−82.3
July......	1944	269.4	−18.6	−86.8
January..	1945	252.0	−17.4	−86.8
July......	1945	235.7	−16.3	−86.8
January..	1946	220.4	−15.3	−86.8
July......	1946	206.1	−14.3	−86.8
January..	1947	192.7	−13.4	−86.8

Average loss ratio July 1940 to January 1944, 86.8.

Decline percentage $\frac{100}{86.8}$ = 1.15 per cent.

Extrapolation until January 1947 by means of average loss ratio, 86.8.

followed in this extrapolation is self-explanatory; the same method that was used to arrive at the loss ratio from the known production rates in the upper half of the tabulation is used in reverse to find the unknown future production rates from the constant loss-ratio values.

Mathematical Analysis[15]

Rate-time Relationship.—The rate-time curve for the case of exponential decline has a constant loss ratio, as shown in the preceding section, which leads to the following differential equation (see list of symbols on page 20):

$$\frac{P}{dP/dt} = -a \qquad [1]$$

in which a is a positive constant. After integration of this equation, and after elimination of the integration-constant by

setting $P = P_0$ for $t = 0$, the following rate-time relationship is obtained:

$$P = P_0 e^{-t/a} \qquad [2]$$

This expression obviously is of the exponential type and explains why such a rate-time curve can be represented as a straight line on semilog paper.

Rate-cumulative Relationship.—The expression for the rate-cumulative curve can be found by simple integration of the rate-time relationship, as follows:

$$C = \int P dt = \int P_0 e^{-t/a} dt \qquad [3]$$

which, after integration, and after elimination of the constant by setting $C = 0$ for $t = 0$, leads to:

$$C = a(P_0 - P) = 100 \frac{(P_0 - P)}{D} \qquad [4]$$

This simple linear relationship indicates that the production rate plotted against the cumulative production should be a straight line on regular coordinate paper.[13]

Monthly Decline Percentage.—The monthly decline percentage as per definition can be represented by:

$$D = -100 \frac{dP/dt}{P} \text{ per cent} \qquad [5]$$

or, with the use of Eqs. 1 and 4:

$$D = \frac{100}{a} = 100 \frac{P_0 - P}{C} \text{ per cent} \qquad [6]$$

In other words, the decline percentage can be found directly from the loss-ratio tabulation (100/86.8 = 1.15 per cent in the example shown in Table 1) and also from the slope of the rate-cumulative curve.

Graphical Extrapolation and Practical Shortcuts

As pointed out before, the rate-time curve for exponential decline will show a straight-line relationship on semilog paper and can, therefore, be extrapolated by continuing the straight line.

The rate-cumulative curve shows a very simple linear equation (Eq. 4) and can, therefore, be represented by a straight-line relationship on regular coordinate paper.

In addition to these methods, some practical shortcuts have been developed recently, which were made possible by the fact that rate-time curves for exponential decline are usually plotted on semilog graph paper.

The gradient of the rate-time curve on semilog paper is constant and equal to $-\frac{1}{a}$. Since the decline percentage is a simple function of a (see Eq. 6), it is possible to make a calculator for standard semilog paper by plotting the constant drop in production rate per year for a given decline on a strip of paper or transparent film. This can be used, then, as a yardstick to read off the decline percentage immediately from the production drop over a one-year interval. By making the width of the calculator equal to one year on the horizontal time scale, the procedure can be simplified even more. Fig. 1 shows how such a calculator can be used for the purpose of determining the monthly decline percentage.

The relationship between cumulative production C and production drop $(P_0 - P)$ in Eq. 4 is a simple multiplication. Since we are already working on paper with a vertical logarithmic scale, it is easy to see that we can apply the slide-rule principle by using the paper on which the curve is plotted as one scale and a graduated strip with a similar logarithmic division as the other scale. By plotting the value of $\frac{100}{D}$ on this strip for various values of the decline percentage D, it is possible to carry the multiplication out on the same graph paper used for the curves, and read the answer on its vertical log scale. Figs. 1 and 2 show how such a calculator, designed for determination of both decline percentage and

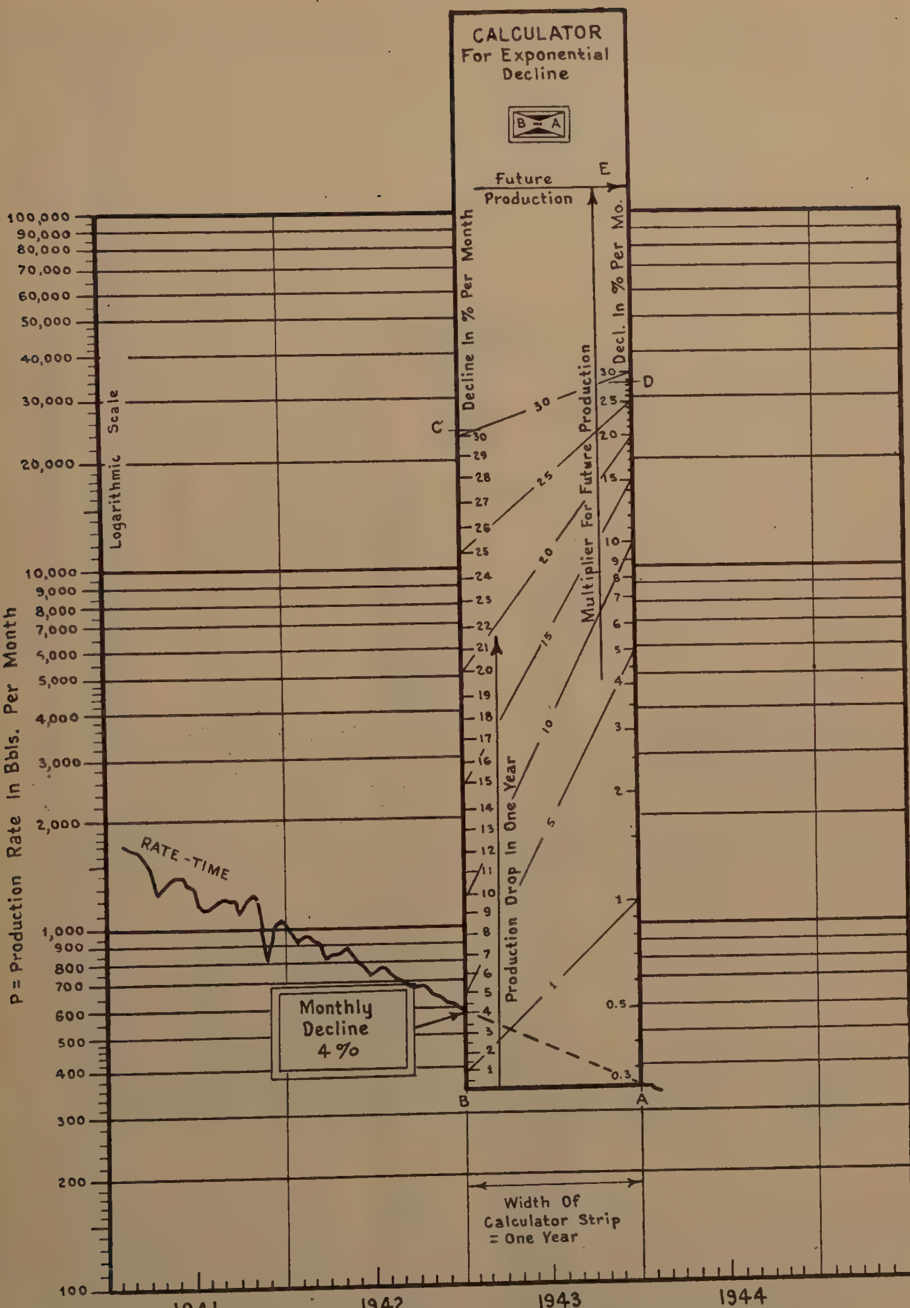

FIG. 1.—USE OF CALCULATOR TO DETERMINE DECLINE PERCENTAGE.

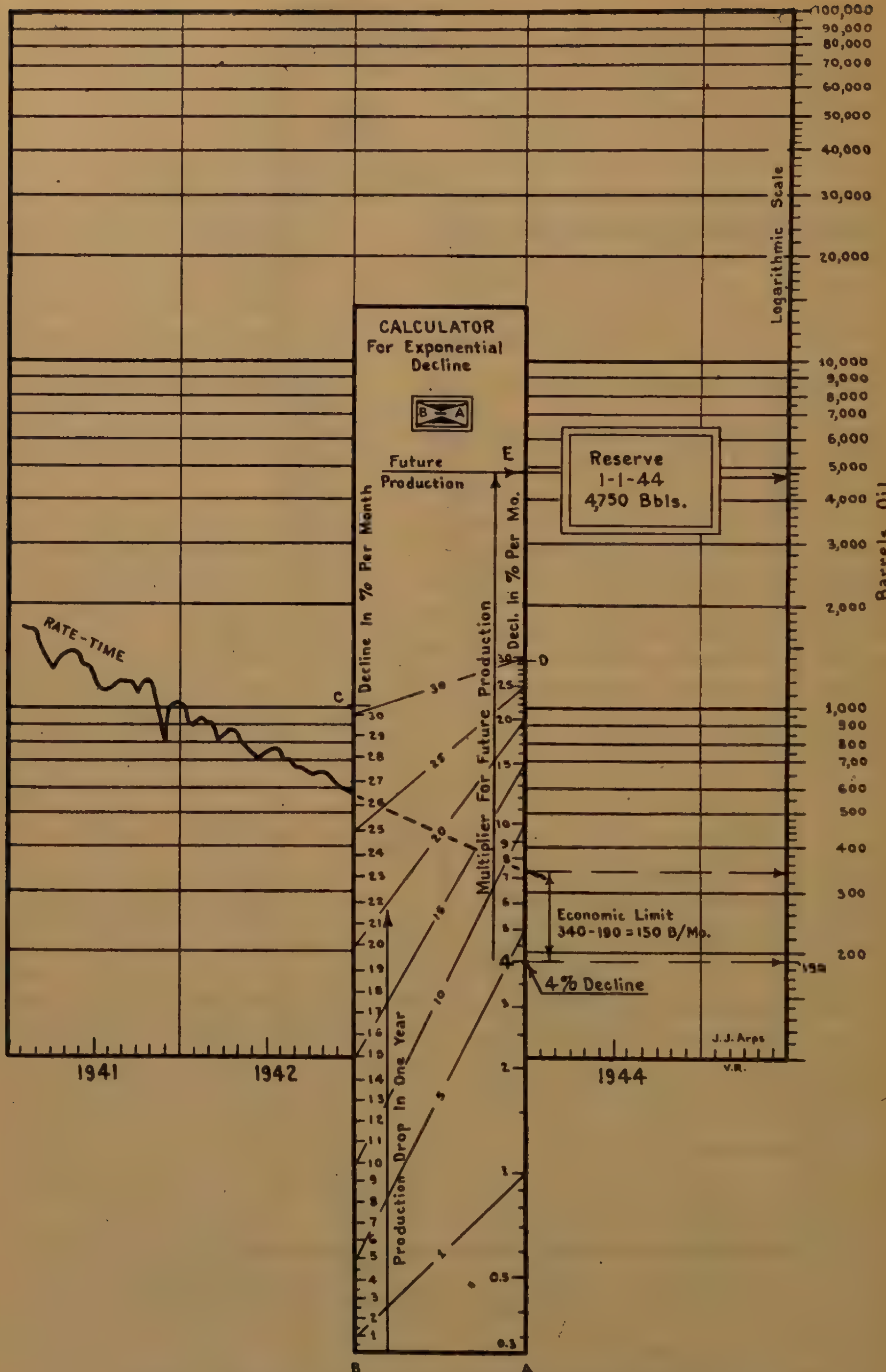

FIG. 2.—USE OF CALCULATOR TO DETERMINE FUTURE PRODUCTION.

future production, is used. The monthly decline percentage was read off from scale BC in Fig. 1 as 4 per cent and the constant matched with this production rate of 190 bbl. per month and the future recovery is read off opposite arrow E as 4750 barrels.

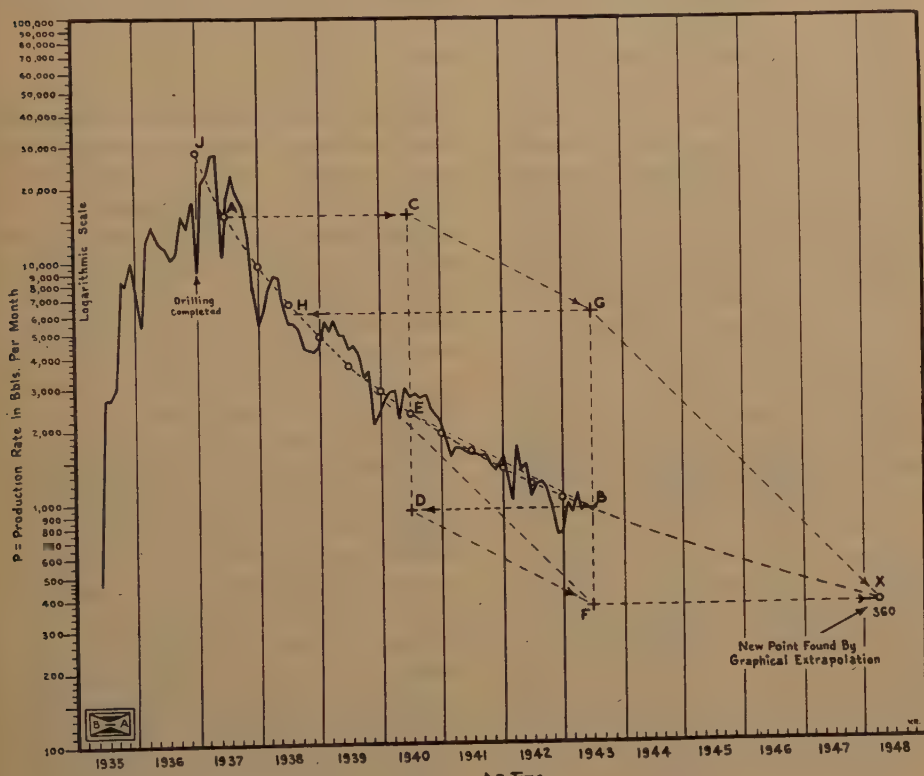

FIG. 3.—GRAPHICAL EXTRAPOLATION OF HYPERBOLIC RATE-TIME CURVE ON SEMILOG PAPER.

Type of curve: $P = P_o\left(1 + \frac{b}{a_o}t\right)^{-\frac{1}{b}}$

1. Smooth out the given curve AB.
2. Draw a vertical line CD midway between A and B.
3. Project A and B horizontally on this middle line and find points C and D.
4. Draw CG and DF parallel to EB.
5. Project G back horizontally on the curve and find point H.
6. Draw GX parallel to HF and find the unknown extrapolated point X at the intersection with the horizontal line through F.

for 4 per cent decline on scale AD was used to find the future production in Fig. 2. The economic limit was assumed to be 150 bbl. per month and the production drop from January 1944 until this economic limit will be reached is, therefore, 340 − 150 = 190 bbl. per month. The constant for 4 per cent decline on scale AD is

Hyperbolic Decline

Statistical Analysis and Extrapolation

The hyperbolic or "log-log" type of decline, which occurs most frequently, can be recognized by the fact that the loss ratios show an arithmetic series and that, therefore, the first differences of the loss

ratios are constant or nearly constant.[12,15] As an example, Table 2 shows the loss ratio for production data from a lease producing from the Arbuckle lime in Kansas. This lease had been producing under conditions of capacity production since the completion of drilling and shows a rate-time curve on semilog paper, curving steadily to the right (Fig. 3). To eliminate irregularities, it was necessary to smooth out the original data (see curve *JB* on Fig. 3). The production rates listed in Table 2 are identical with the circles on the curve in Fig. 3.

TABLE 2.—*Loss Ratio for Lease Producing from Arbuckle Lime in Kansas*
(TYPICAL CASE OF HYPERBOLIC DECLINE)

Month	Year	Monthly Production Rate, P (Curve JB, Fig. 3)	Loss In Production Rate during 6 Months Interval, ΔP	Loss Ratio on Monthly Basis, $a = 6\frac{P}{\Delta P}$	First Derivative of Loss Ratio, $b = \frac{\Delta\left\{\frac{6P}{\Delta P}\right\}}{6}$
Jan...	1937	28,200			
July..	1937	15,680	−12,520	− 7.52	
Jan...	1938	9,700	− 5,980	− 9.72	−0.37
July..	1938	6,635	− 3,065	−12.97	−0.54
Jan...	1939	4,775	− 1,860	−15.39	−0.40
July..	1939	3,628	− 1,147	−18.96	−0.59
Jan...	1940	2,850	− 778	−21.96	−0.50
July..	1940	2,300	− 550	−25.08	−0.52
Jan...	1941	1,905	− 395	−28.95	−0.64
July..	1941	1,610	− 295	−32.76	−0.63
Jan...	1942	1,365	− 245	−34.43	−0.28
July..	1942	1,177	− 188	−36.97	−0.42
Jan...	1943	1,027	− 150	−41.15	−0.70
July..	1943	904	− 123	−44.20	−0.508
Jan...	1944	802	− 102	−47.25	−0.508
July..	1944	717	− 85	−50.30	−0.508
Jan...	1945	644	− 73	−53.35	−0.508
July..	1945	582	− 62	−56.40	−0.508
Jan...	1946	529	− 53	−59.45	−0.508
July..	1946	483	− 46	−62.50	−0.508
Jan...	1947	442	− 41	−65.55	−0.508
July..	1947	406	− 36	−68.60	−0.508
Jan...	1948	375	− 31	−71.65	−0.508
July..	1948	347	− 28	−74.70	−0.508

First derivative of loss ratios approximately constant; average $b = -0.508$.
Extrapolation until July 1948 by means of this average b value of -0.508.

As in the case of exponential decline, the production rates were posted at six-month intervals to eliminate monthly fluctuations and to embrace the general trend of the curve without too much work. Since the loss ratio a is defined as the production rate divided by the first derivative of the rate-time curve, a factor 6 was introduced to find the proper values. The loss ratios thus obtained indicated a fairly uniform arithmetic series and consequently the differences between successive loss-ratio values b are reasonably constant. The average is 0.508.

These differences represent the derivatives of the loss ratios with respect to time, and since six-month intervals are used, a correction factor of $\frac{1}{6}$ was introduced to find the proper values of b. The average value for b was used to extrapolate the curve to July 1948 by reversing the process used in the upper part of the tabulation. From these data, it is evident that the lease can be expected to reach its economic limit of 400 bbl. per month during the second half of 1947.

As will be shown later, the mathematical equations of the rate-time and rate-cumulative curves for hyperbolic decline are essentially of the same type and it is therefore also possible to use the loss-ratio method for extrapolation of rate-cumulative data. The only difference from the procedure in Table 2 is that the time column is replaced by cumulative production figures, and that the intervals therefore may not be constant. The loss ratio in that case is the production rate at a given point divided by the ratio of the drop in production rate to the total production during the preceding interval. In a similar way, the first derivative should be determined as the increase in loss ratio over the given interval divided by the total production during the same interval. In hyperbolic decline, the first derivative should be approximately constant. To extrapolate the data and find the ultimate recovery for a given economic limit, the average first derivative can be used to extrapolate the tabulation in a manner similar to that of Table 2.

Mathematical Analysis

1. *Rate-time Relationship.*—When the first differences of the loss ratios are

approximately constant, as in Table 2, the following differential equation can be set up:

$$\frac{d\left(\dfrac{P}{dP/dt}\right)}{dt} = -b \qquad [7]$$

in which b is a positive constant. Integration of Eq. 7 leads to:

$$\frac{P}{dP/dt} = -bt - a_0 \qquad [8]$$

in which a_0 is a positive constant, representing the loss ratio for $t = 0$. Eq. 8 can be simplified to:

$$\frac{dP}{P} = -\frac{dt}{a_0 + bt} \qquad [9]$$

This second differential equation can be integrated and the constants eliminated by setting $P = P_0$ for $t = 0$, which results in the rate-time relationship for hyperbolic decline:

$$P = P_0\left(1 + \frac{bt}{a_0}\right)^{-1/b} \qquad [10]$$

This expression, which is obviously of the hyperbolic type, explains why such a curve can be straightened on log-log paper. It also shows that horizontal shifting to the right over a distance $\frac{a_0}{b}$ is necessary for such straightening. The slope of the straight line on log-log paper thus obtained will be $-\frac{1}{b}$.

Rate-cumulative Relationship.—To find the rate-cumulative relationship for this case, the above rate-time curve can be integrated as was done for the exponential decline curve:

$$C = \int P dt = \int P_0\left(1 + \frac{bt}{a_0}\right)^{-1/b} dt \qquad [11]$$

After carrying out the integration for the case where b is not equal to unity, and keeping in mind that the cumulative production $C = 0$ at time $t = 0$, the following relationship is obtained:

$$C = \frac{a_0 P_0}{b - 1}\left\{\left(1 + \frac{bt}{a_0}\right)^{1-1/b} - 1\right\} \qquad [12]$$

or after eliminating t with the rate-time relationship in Eq. 10:

$$C = \frac{a_0 P_0^b}{1 - b}\left(P_0^{1-b} - P^{1-b}\right) \qquad [13]$$

In the special case, where $b = 1$, the integration results in the expression for harmonic decline as can be easily verified:

$$C = a_0 P_0 (\log P_0 - \log P) \qquad [14]$$

The rate-cumulative relationship in Eq. 13 can apparently also be straightened on log-log paper after horizontal shifting on the cumulative scale, while the relationship in Eq. 14 can be represented by a straight line on semilog paper with the production rate plotted on the log scale.

Monthly Decline Percentage.—From Eq. 8, it can be found that the monthly decline for this case is:

$$D = -100\frac{dP/dt}{P} = \frac{100}{a_0 + bt} \text{ per cent} \qquad [15]$$

After elimination of t with Eq. 10, it is found that:

$$D = \frac{100}{a_0 P_0^b} P^b \text{ per cent} \qquad [16]$$

or, in other words, that in the case of hyperbolic decline, the decline percentage is proportional to the power b of the production rate. This is a very interesting result. It means that if a hyperbolic decline curve has a first difference in the loss ratio of say -0.5, the decline percentage is proportional to the square root of the production rate. This means that if such a well has a 10 per cent decline when the production rate was 10,000 bbl. per month, it will slow down to 1 per cent by the time

the production rate has dropped to 100 bbl. per month.

Three-point Rule.—The hyperbolic decline curve shows another interesting feature, which can sometimes be used to advantage. It can be expressed as: "For any two points on a hyperbolic rate-time curve, of which the production rates are in a given ratio, the point midway between will have a production rate which is a fixed number of times the rate of either the first or last point, regardless of where the first two points are chosen."

In other words, if on a curve with an exponent $b = 0.5$, the first point has a production rate of $2A$ bbl. and the last point a rate of A bbl., the point midway between will have a value of $1.374A$ bbl., regardless of where the first set of points is selected on the curve and regardless of the time interval. The validity of this statement can be shown as follows:

According to Eq. 10, the production rates at time $t - v$, t and $t + v$ will be:

$$P_{t-v} = P_0 \left\{1 + \frac{b}{a_0}(t - v)\right\}^{-1/b} \quad \text{or} \quad P_{t-v}^{-b} = P_0^{-b}\left\{1 + \frac{b}{a_0}(t - v)\right\} \qquad [17]$$

$$P_t = P_0\left(1 + \frac{b}{a_0}t\right)^{-1/b} \quad \text{or} \quad P_t^{-b} = P_0^{-b}\left(1 + \frac{b}{a_0}t\right) \qquad [18]$$

and

$$P_{t+v} = P_0 \left\{1 + \frac{b}{a_0}(t + v)\right\}^{-1/b} \quad \text{or} \quad P_{t+v}^{-b} = P_0^{-b}\left\{1 + \frac{b}{a_0}(t + v)\right\} \qquad [19]$$

By adding together the right sides of Eqs. 17 and 19, the time interval v is eliminated and an expression is obtained that is twice the value of the right side of Eq. 18. Therefore:

$$2P_t^{-b} = P_{t-v}^{-b} + P_{t+v}^{-b} \qquad [20]$$

If the rate at the first point is n times the rate at the last point, the value of the rate at the middle point (P_t) can be expressed as:

$$P_t = \left(\frac{n^{-b} + 1}{2}\right)^{-\frac{1}{b}} P_{t+v} \qquad [21]$$

This relationship was used advantageously for a simple graphical extrapolation construction for the hyperbolic-type decline curve on semilog paper as illustrated by Fig. 3 and discussed hereafter.

Graphical Extrapolation Methods

Log-log Paper.—As pointed out before, both the rate-time and rate-cumulative curves for hyperbolic decline can be represented and extrapolated as straight lines on log-log paper after some shifting. The rate-cumulative curve for the special case of harmonic decline where $b = 1$, however, can be straightened only on semilog paper.

Log-log paper extrapolation has the disadvantage of giving the least accuracy at the point where the answer is required; it is also somewhat laborious on account of the extra work involved in shifting until the best straight-line relationship is found.

Semilog Paper.—Although log-log paper is used to a large extent for production curves of the hyperbolic type, there are still some companies that continue to plot their production curves on semilog paper, even though the decline may be of the hyperbolic type. The reason seems to be that this procedure allows a wide range in small space on the vertical log scale and at the same time has a simple linear horizontal time scale. The curvature in the rate-time relationship for this case, however, makes extrapolation difficult and uncertain.

With the help of the "three-point rule" for hyperbolic decline, it is now possible to extrapolate such a curved hyperbolic rate-time curve on semilog paper with a fair degree of accuracy by simple graphical construction. This procedure is shown on Fig. 3. Three points, A, E and B, are

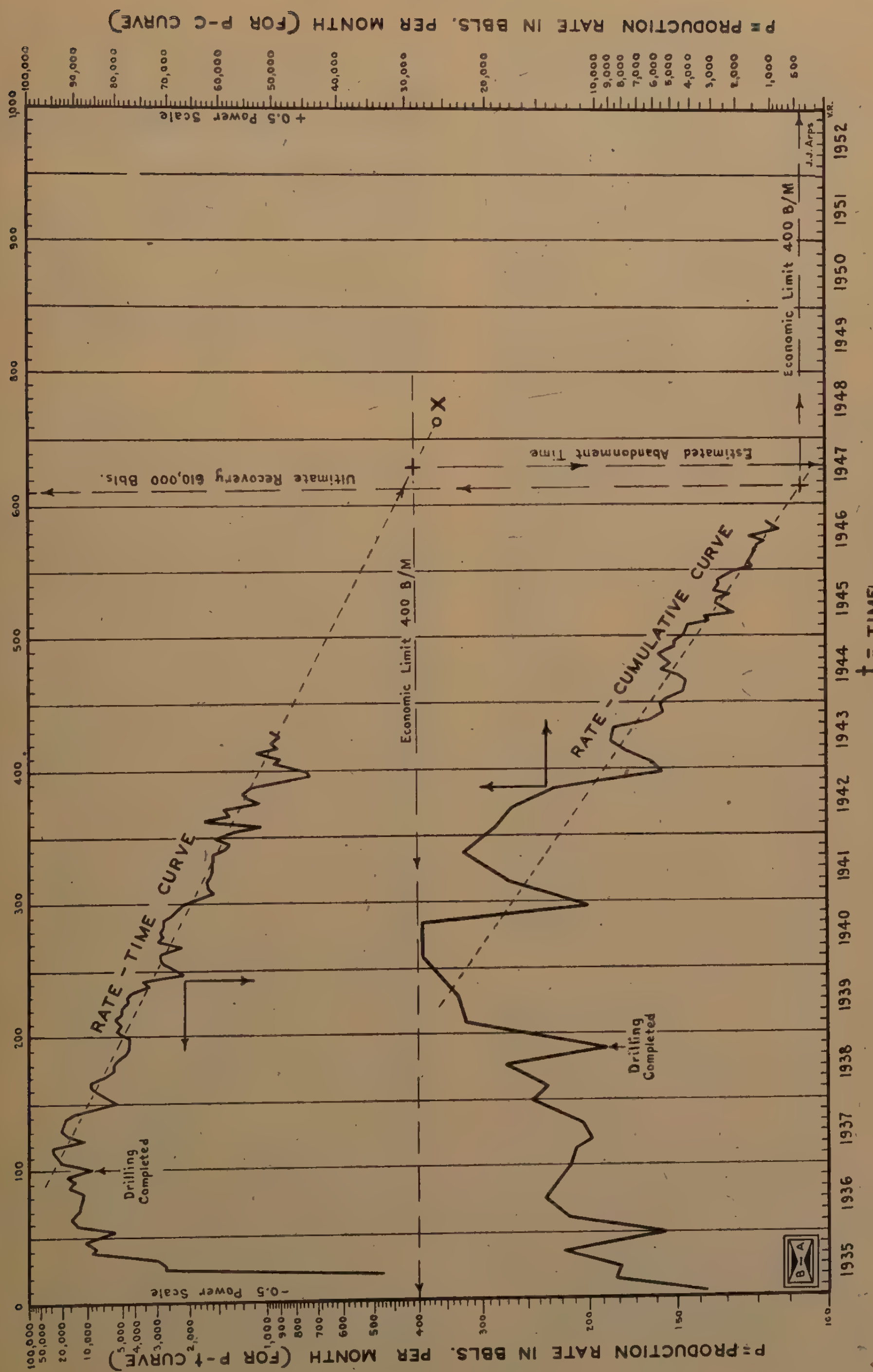

FIG. 4.—STRAIGHT-LINE DECLINE CHART FOR HYPERBOLIC DECLINE. $b = 0.5$.
To be used for production curves where decline is proportional to the square root of the production rate.
Illustrated with data from a Kansas lease, producing from the Arbuckle lime.

selected at equal time intervals on the smoothed-out curve AB. Then, according to the three-point rule the relative value of the middle point E is a simple function of the ratio of the first and third points A and B, regardless of the time interval or the location on the curve. Transfer of the value of these ratios is possible by drawing simple parallel lines, because the vertical scale is logarithmic. In the construction, the third point B is used as the middle point of a new set of three equidistant points whose ratios are identical with those originally selected. The third point of this new set of three is found by the construction shown on Fig. 3, which is self-explanatory, and it represents a new extrapolated point of the curve. The method can be used for both rate-time and rate-cumulative curves, provided they are of the hyperbolic type, and provided the construction is carried out on semilog paper.

Special Straight-line Charts.—It may be noted from Eq. 10 and 13 that the behavior of the hyperbolic-type decline curve is governed primarily by the value of the exponent b, the first differential of the loss ratio. When the value of b is zero, the decline curve is of the simple exponential or constant percentage type. Some mention is found in the literature of hyperbolic decline with a value of $b = 1$, which was called harmonic decline.

To find the practical range of this exponent b from actual production curves, the data assembled by W. W. Cutler[8] was used. He published the coordinates of a large number of hyperbolic field-decline curves. From his data the exponent b was calculated for each case. The results are shown in Table 3. According to this tabulation, the value of b in the majority of cases appears to be between 0.0 and 0.4. The b value equal to unity is, according to Cutler's data, very rare. In the writer's experience, however, this type decline does occur occasionally.

TABLE 3.—*Value of b According to Cutler's Data*[8]

Exponent b Between	Number of Cases	Exponent b Between	Number of Cases
0.0 and 0.1......	19	0.4 and 0.5....	15
0.1 and 0.2......	41	0.5 and 0.6....	9
0.2 and 0.3......	27	0.6 and 0.7....	4
0.3 and 0.4......	34	Above 0.7.....	None

The rate-time and rate-cumulative relationship in Eqs. 10 and 13 can be rewritten as:

$$P^{-b} = P_0^{-b}\left(1 + \frac{b}{a_0}t\right) \qquad [22]$$

and

$$P^{1-b} = P_0^{1-b}\left(1 - \frac{1-b}{a_0P_0}C\right) \qquad [23]$$

In both equations the right-hand side is linear in either time or cumulative while the left-hand side is an exponential function of the production rate P. The exponent in Eq. 22 is $-b$; in Eq. 23 it is $1 - b$. In other words, if a vertical scale could be arranged in such a manner that the ordinate for P would represent a distance P^{-b} for the rate-time curve and P^{1-b} for the rate-cumulative curve, a straight-line relationship should result for both. The horizontal scale could remain linear and no shifting would be necessary. At the same time, the accuracy of reading the extrapolated remaining life or the ultimate recovery on the linear scale would be better than with the log-log method.

Since most decline curves seem to be characterized by b values between 0 and 1, with the majority between 0 and 0.4, a set of so-called "straight-line decline charts" was prepared for successive values of b. The vertical scales were prepared simply by calculating and plotting a series of values for P^{-b} and P^{1-b}. It was found that a highly accurate determination of b is usually unnecessary for most practical purposes and that for ordinary appraisal work a set of charts for b values of 0, 0.25, 0.5 and 1.0 is sufficient.

The chart for $b = 0.5$ is shown in Fig. 4 and the data from Table 2 are plotted on this chart to show the straight-line extrapolation procedure. The scale on the right should be used in conjunction with the linear cumulative scale on the top of the chart, while the scale on the left should be used in combination with the linear

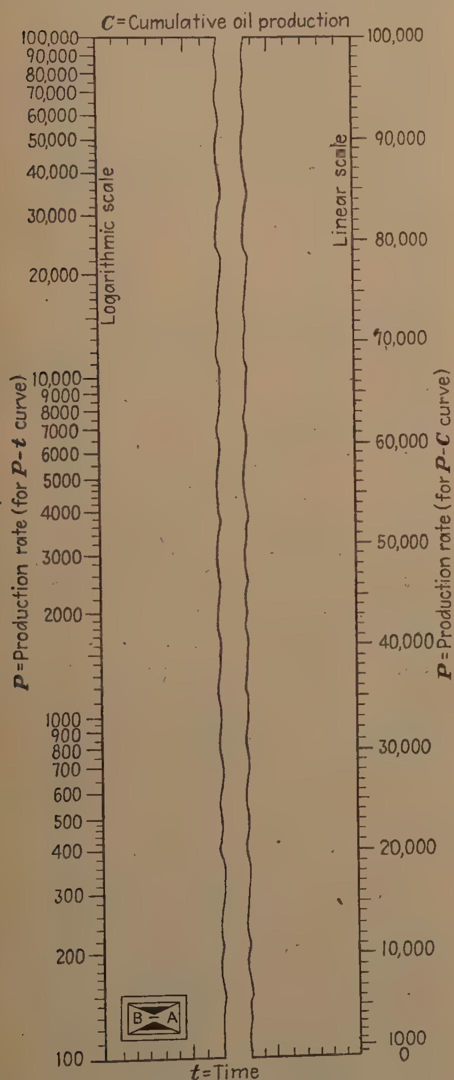

FIG. 5.—STRAIGHT-LINE DECLINE CHART FOR EXPONENTIAL DECLINE.
a = constant; b = 0.
(For curves with constant decline.)

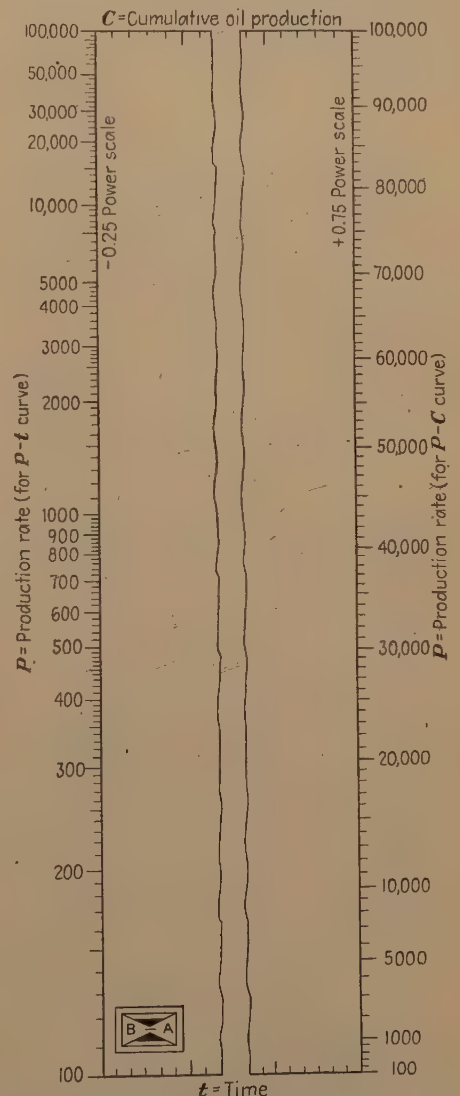

FIG. 6.—STRAIGHT-LINE DECLINE CHART FOR HYPERBOLIC DECLINE.
$b = 0.25$.
(To be used if decline is proportional to the ¼ power of the production rate.)

is designed to match the b value of the one on the left, so that it will fit the rate-cumulative relationship. The scale on the time scale on the bottom. Both curves can then be plotted and extrapolated as

straight lines, simultaneously. Vertical scales for similar charts, designed for b values of 0, 0.25 and 1.0 are shown in Figs. 5, 6 and 7, respectively.

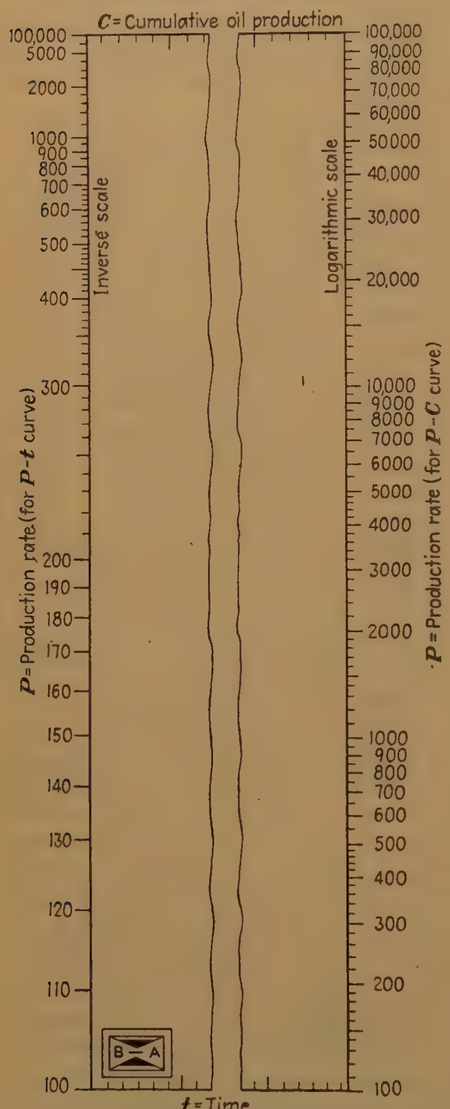

FIG. 7.—STRAIGHT-LINE DECLINE CHART FOR HARMONIC DECLINE.
$b = 1$.
(To be used if decline is proportional to the production rate.)

To determine which chart should be used, the three-point rule can be used: Two points are selected on the available curve in such a manner that the production rate of the first point is twice the rate at the last point. The production rate at the midway point is then read off and its ratio to the last point determined. If this ratio has a value between 1.414 and 1.396, the chart for $b = 0$ should be used; if it is between 1.396 and 1.383, the chart for $b = 0.25$ will be better; if it is between 1,383 and 1.352, the chart for $b = 0.50$ should be preferred, and if the ratio is between 1.352 and 1.333 the chart for harmonic decline ($b = 1$) will give the best results. If these ratios are too close together, other values can be calculated with the help of Eq. 21.

A simpler method is to plot the rate-time curve on semilog paper ($b = 0$) and if it shows a persistent curvature three representative points should be replotted on the chart for $b = 0.5$. If the three points do not lie on a straight line, but show curvature to the right, the chart for $b = 1$ should be selected; if the curvature is downward, the chart for $b = 0.25$ should give better results.

Another method is to set up a loss-ratio tabulation and actually determine the average value of the first differential b. The chart with the closest b value should then be chosen. This method was followed in Table 2, and since the b value obtained (0.508) was very close to 0.50, the chart for this latter value was used (Fig. 4).

OTHER EMPIRICAL DECLINE CURVES

In addition to the exponential type of decline, which is the simplest empirical relationship and has found widespread application for approximate estimates because of its simplicity, and the hyperbolic type of decline, which is more complicated, but also generally more accurate, there are several empirical equations that can sometimes be used to represent production-decline curves if the simpler types are inadequate. Three of the more important types are discussed in the following pages.

Loss Ratios Form a Geometric Series (Ratio Decline)

A curve of this type has the characteristic that the decline percentage-time relationship is similar to the rate-time relationship for exponential decline and can be plotted as a straight line on semilog paper. In other words, the decline fraction itself is declining at a constant percentage per month. The differential equation for the rate-time curve is:

$$\frac{P}{dP/dt} = a_0 r^t \qquad [24]$$

in which r is the constant ratio of two successive values of the loss ratio a. After integration this leads to:

$$P = P_0 e^{\frac{(1-r^{-t})}{a_0 \log r}} \qquad [25]$$

The simplest way to recognize this type of decline, and to extrapolate it, is by means of the loss-ratio tabulation. The equation for the rate-cumulative curve, which can be found by integration of Eq. 25, is too complicated for practical use. As an example of the statistical treatment of production curves of this type, Table 4 shows a loss-ratio tabulation of the family decline curve from a Wilcox sand pool in Oklahoma. As before, the per well production rates at equal time intervals are tabulated in column 3, the drop in production rate in column 4 and the loss ratio in column 5. In this case the loss ratios form approximately a geometric series. This is evidenced by the fact that the figures in column 6, which represent the ratios of successive loss-ratio values, are approximately constant. Their average value is 1.127 and this figure was used for the extrapolation of column 6 in the lower half of the table. The extrapolated values for the production rate were then found by reversing the process used in the upper part of the tabulation.

TABLE 4.—*Loss Ratio for the Family Decline Curve of a Field Producing from the Wilcox Sand in Oklahoma*
(TYPICAL CASE OF RATIO DECLINE)

Month	Year	Monthly Production Ratio, P	Loss In Production Rate during 6 Months Interval, ΔP	Loss Ratio, on Monthly Basis, $a = 6\frac{P}{\Delta P}$	Ratio of Successive Loss Ratios, $r^6 = \frac{a_n}{a_{n-1}}$
Jan...	1	20,360			
July..	1	13,260	−7,100	−11.206	
Jan...	2	8,990	−4,270	−12.632	1.127
July..	2	6,390	−2,600	−14.746	1.167
Jan...	3	4,650	−1,740	−16.034	1.087
July..	3	3,490	−1,160	−18.052	1.126
Jan...	4	2,700	− 790	−20.506	1.136
July..	4	2,140	− 560	−22.929	1.118
Jan...	5	1,740	− 400	−26.100	1.138
July..	5	1,440	− 300	−28.800	1.103
Jan...	6	1,220	− 220	−33.273	1.155
July..	6	1,050	− 170	−37.059	1.114
Jan...	7	918	− 132	−41.769	1.127
July..	7	814	− 104	−47.078	1.127
Jan...	8	731	− 83	−53.062	1.127
July..	8	664	− 67	−59.806	1.127
Jan...	9	610	− 54	−67.407	1.127
July..	9	565	− 45	−75.974	1.127
Jan...	10	528	− 37	−85.631	1.127
July..	10	497	− 31	−96.514	1.127

The ratio of successive loss ratios is approximately constant; average value, 1.127.
Extrapolation until the tenth year, in the lower half of the tabulation, by means of this average value

First Derivatives of Loss Ratios Form an Arithmetic Series

The first derivatives of the loss ratios form an arithmetic series and the second derivatives are constant. S. T. Pirson[15] worked out the three possible mathematical solutions for the rate-time equations, and complete details may be found in his paper. It has been found that these equations are generally too complicated for practical use. The simplest way to extrapolate a curve, showing these characteristics, is by means of the loss-ratio method.

Straight-line Relationship between Decline Percentage and Time on Log-log Paper

This type of decline was discussed in a general way on pages 4 to 5, and for more details we refer to the original article by P. J. Jones.[21]

Aside from the fact that there is a straight-line relationship between decline

and time on log-log paper, this type of curve can also be extrapolated as a straight line by plotting the log-log of the production rate against the log of the time. Statistical extrapolation by means of the loss-ratio method is possible but too complicated for practical use.

Tentative Classification of Decline Curves, Based on Loss Ratio

To summarize the discussions in this paper, a tabulation was prepared (Table 5) showing the mathematical interrelationship between the commoner types of decline curves. At the same time, it is shown how these decline curves can be classified according to the loss-ratio method.

If the loss ratio is constant, the decline curve must be of the exponential type. If the loss-ratio figures are not constant, but form an arithmetic series, the decline will be of the hyperbolic or harmonic type, depending on the value of the increment b. If the loss-ratio figures indicate a geometric series, the curve must be of the ratio-decline type.

On this table is shown also a summary of the graphical and other methods that can be used to extrapolate the different types of curves.

Summary

Most production-decline curves can be classified into a few simple types, which can be recognized by graphical, statistical

TABLE 5.—*Tentative Classification of Decline Curves, Based on Loss Ratios*

Time, t; production rate, P; drop in production rate, ΔP

	Loss Ratio, $a = \frac{P}{\Delta P}$	Differential of Loss Ratio, $b = \Delta a = \Delta\left(\frac{P}{\Delta P}\right)$		Ratio of Successive Loss Ratios, $r = \frac{a_n}{a_{n-1}}$
Loss ratios or a values	Constant	Arithmetic Series		Geometric Series
Type of decline	$a = \frac{P}{\Delta P}$ = Constant Then: Exponential or Constant Percentage Decline	$b = \Delta a$ = Constant ($0 < b < 1$) Then: Hyperbolic Decline	$b = \Delta a = 1$ Then: Harmonic Decline	$r = \frac{a_n}{a_{n-1}}$ = Constant Then: Ratio Decline
Rate-time relationship (P, t)	$P = P_0e^{-t/a}$ (Straight line on semilog paper)	$P = P_0\left(1 + \frac{b}{a_0}t\right)^{-1/b}$ (Straight line on special decline charts. Straight line on log-log paper after shifting)	$P = \frac{P_0}{\left(1 + \frac{t}{a_0}\right)}$	$P = P_0e^{\frac{(1-r^{-t})}{a_0 \log r}}$
Cumulative-rate relationship (C, P)	$C = a(P_0 - P)$ (Straight line on coordinate paper	$C = \frac{a_0P_0^b}{1-b}(P_0^{1-b} - P^{1-b})$ (Straight line on special decline charts) (Straight line on log-log paper after shifting)	$C = a_0P_0(\log P_0 - \log P)$ (Straight line on semilog paper)	Too complicated
Decline percentage (D)	$D = \frac{100}{a}$ Decline constant	$D = \frac{100}{a_0P_0^b}P^b$ (Straight line on log-log paper) Decline proportional to power b of production rate	$D = \frac{100}{a_0P_0}P$ (Straight line on coordinate paper) Decline proportional to production rate	$D = \frac{100}{a}r^{-t}$ (Straight line on semilog paper) Decline diminishing with time at constant percentage (geometric series)
Graphical shortcuts on semilog paper	Special decline calculator	Graphical extrapolation construction based on "three-point rule"		

or mathematical means. There is a distinct interrelationship between these types and a detailed study revealed some new characteristics and possibilities for simplification of the extrapolation procedure. Among these, the most important are:

1. A decline calculator to be used for exponential decline curves plotted on semilog paper. This calculator, which is based on the slide-rule principle, makes it possible to read off the monthly decline percentage and the future reserve directly from the original curve.

2. The mathematical relationship between rate-time, rate-cumulative and rate-decline percentage for hyperbolic and harmonic decline.

3. A graphical construction method for extrapolation of hyperbolic-type decline curves, plotted on semilog paper. This method is based on the three-point rule, which is a mathematical connection between the production rates of three equidistant points on the curve.

4. The introduction of straight-line decline charts for hyperbolic decline. These charts have vertical scales arranged in such a manner as to make straight lines out of both rate-time and rate-cumulative curves, belonging to the hyperbolic type. Use of these charts facilitates extrapolation of this type of production curves considerably.

Acknowledgement

The author wishes to express his appreciation to Mr. C. D. Miller, Vice-President in Charge of Production for The British-American Oil Producing Co., for permission to publish this paper.

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Symbols

- P, production rate, bbl. per month.
- P_0, initial production rate, bbl. per month.
- t, time elapsed since first production, months.
- v, constant time interval.
- C, cumulative production from completion until time t, bbl.
- a, positive number, representing loss ratio on a monthly basis.
- a_0, positive number, representing loss-ratio during first month.
- b, positive number, representing first derivative of loss ratio.
- D, decline, per cent per month.
- D_0, initial decline, per cent per month.
- A, B, n, m, various constants.
- r, ratio of successive loss ratios.
- log, natural logarithm.
- e, base of natural logarithm.

Significance of Declining Productivity Index

By C. V. Millikan* and Herbert F. Beardmore,† Members A.I.M.E.

(Houston Meeting, May 1944)

Abstract

Declining Productivity Index, as considered herein, is a productivity index that has a substantially and consistently decreasing value when measured over a period of a few hours. If not recognized, it may be interpreted as representing an unsettled or unstable condition in a producing well. It forms the basis of a number of predictions as to future performance compared with the performance of wells in which the productivity index does not decline. The most important of these are that: (1) the rate of oil production will decline more rapidly, (2) the gas-oil ratio will usually increase abnormally, (3) the amount of water ultimately produced will be negligible, if any, (4) stop-cocking will increase current production and decrease gas-oil ratio. When such relative well performance is indicated, it follows that certain reservoir performance and operating practices may be anticipated: (1) disappointing recovery, (2) longer natural flow, (3) no active water drive, (4) better evaluation of acidizing, shooting and reworking, (5) intermittent operation of wells, (6) smaller pumping equipment required. It is significant that the basis of these important predictions is bottom-hole pressure tests that can be made immediately after completion of the wells.

Introduction

"Productivity index" is the number of barrels of oil produced per day per pound per square inch of differential pressure between the reservoir and the bottom of the well. "Declining Productivity Index," as considered herein, is a productivity index that has a substantially and consistently decreasing value when measured over a period of a few hours.

Productivity index can be determined only when the rate of production can be stabilized. In most wells the rate of production and bottom-hole pressure are easily stabilized to give a constant productivity index for a period of many hours. A few produce so erratically as to preclude probability of an acceptable test in the usual sense. A satisfactory productivity index can be determined in some wells only by gauging the production accurately by hours, measuring the bottom-hole pressure continuously, and from these data calculating the productivity index for successive hours. Such figures frequently will have a decreasing value—that is, a declining productivity index—and when plotted on double logarithmic cross-section paper with productivity index as ordinate and time as abscissa will be a straight-line curve. The angle between the curve and the abscissa is referred to as the rate of decline.

Declining productivity index may appear to be the result of change in permeability to oil due to decreasing saturation of oil and increasing saturation of gas in the reservoir. It is possible that such is in fact the cause, but if so, more is involved than merely relative saturation of oil and gas. This seems evident because the rate of decline in productivity index is substantially the same regardless of the pro-

Manuscript received at the office of the Institute Feb. 9, 1945. Issued as T.P. 1872 in Petroleum Technology, July 1945.

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duction rate, and regardless of whether the flowing bottom-hole pressure is above or below the bubble point. Furthermore, during a test the gas-oil ratio increase is generally small, if any. It is believed that a reservoir characteristic, probably a type of porosity, is basically responsible for the type of declining productivity index discussed herein.

Significance of Declining Productivity Index

The history and performance of many wells having a declining productivity index have been sufficiently consistent to make certain qualitative predictions as to future performance of such wells seem reasonably safe, compared with the performance of wells that have a similar reservoir thickness, productive capacity, and other conditions, but do not have a declining productivity index. These predictions of relative performance may be summarized as: (1) the rate of oil-production decline will be more rapid, (2) the gas-oil ratio usually will increase more rapidly and reach a higher value, (3) the amount of water produced ultimately will be small, if any, (4) productivity index will be restored when the well is produced again after having been shut in.

A well having a declining productivity index will usually show a decline in production during the first hours it is produced if the rate of production approaches capacity. The production decline continues and in many cases the well will ultimately go completely dry of oil but still produce gas. There is no period in the life of the well at which the production rate may be called "settled." Such conditions mean low ultimate recovery. This, as stated above, is only relative to the recovery that would be estimated based on the conditions known early in the life of the well without benefit of knowledge of the declining productivity index.

An increasing gas-oil ratio is normal when the primary recovery agent is gas. Experience has been that in most fields the gas-oil ratio becomes even higher in wells with a declining productivity index. Because of the higher gas-oil ratio, wells produce by natural flow to a lower rate of production, and the time that artificial lifting equipment must be installed is delayed. A well does not ordinarily produce at a greater rate when artificial lifting is started than the rate at which it had been producing by natural flow, so that the lifting equipment need not be larger than required to lift the quantity of oil currently produced. The rate of production decline may be less for a few weeks, after which the decline is resumed at the same rate, or only slightly lower, than before.

Water has not been produced in an appreciable quantity from a well having a declining productivity index. Therefore, a pool in which the wells have a declining productivity index would not be expected to have an active water drive. This prediction would influence estimation of reserves, development of the pool and selection of well equipment.

Restoration of productivity index when a well is shut in is characteristic of wells having a declining productivity index. The productivity index will decline as long as the well continues to produce through a choke of a given size. When the well is shut in, the bottom-hole pressure builds up at a slower rate. As the bottom-hole pressure builds up, the initial productivity index will increase, reaching the same initial productivity index as before, when the pressure is the same. Because of this restoration of productivity index, most such wells can be operated intermittently and obtain equal or greater current production with a lower gas-oil ratio than when producing continuously. The optimum periods of intermitting vary, but in general during the early life the period is a few

hours, while later the well may be shut in one or two days each week.

Restoration of productivity index has been responsible occasionally for favorable results attributed to cleaning out, acid treating, shooting, or other work that required a period of shut-in time. Some wells would have had the same increase in production by merely shutting them in for the same length of time.

The magnitude of such relative performance is related to the rate of decline of the productivity index. Wells in some pools have such a high rate of productivity index decline that even on short tests there is enough decline in the production rate to indicate poor recovery. Where the rate of productivity index decline is low, it is difficult to evaluate its influence on the predicted performance. In most pools the wells either do not have a declining productivity index, or the rate of decline is so low that it cannot be measured by a test of reasonable duration and present methods of measurement.

It has been found that the rate of decline of the productivity index is substantially the same, regardless of the rate at which the well is produced.

The procedure in determining declining productivity index is essentially the same as might be used in determining any productivity index. The well is shut in preferably until substantially static conditions are established. It is then produced through a given size of choke, which is not changed during the test, and a gauge of oil production is taken each hour, using every precaution to obtain accuracy. Hourly stock-tank production is corrected for changes in amount of oil in the tubing and in the annular space between the tubing and casing. The production for each two hours is averaged to determine the rate of production on the hour. To gain accuracy of differential pressure during the first part of the test, the bottom-hole pressure gauge is left in the well at the pressure point for a period of at least 10 hr. to obtain a continuous pressure record. The rate in barrels per hour each hour is divided by the pressure decline from the static or initial pressure to the end of the hour to obtain the hourly productivity index. The length of the test may vary, 24 hr. usually being sufficient, although frequently a shorter period will give an acceptable test. When a test runs for several days, it may be satisfactory to lengthen the gauging period. After the first 24 or 48 hr., the average hourly production for each 24-hr. period is determined, and the bottom-hole pressure is measured at the middle of the period. The hourly productivity index for a number of successive hours having been determined, the data are plotted for analysis on double logarithmic cross-section paper, productivity index on the ordinate and time in hours on the abscissa. The plotted points usually form a straight-line curve.

Declining productivity index is not characteristic of any one formation or area. Thus far, it has been found more frequently in lime, dolomite and calcareous sand reservoirs than in true sand reservoirs. It is found in wells in the Gulf Coast, West Texas and Mid Continent areas, and there is evidence that it is present in other areas. The wells may be small or have very large potentials. Occasionally it is found in a well in a pool in which most of the wells do not have a declining productivity index, but such wells usually are recognized at completion as being poor.

The more general characteristics of wells having a declining productivity index have been discussed and are those which may be reasonably anticipated. The detailed test made to determine declining productivity index often gives other information on the well or the pool, particularly the effectiveness of acidizing, shooting and cleaning out. Several flow tests taken in wells having a declining productivity index are presented to show

more clearly the type of information and interpretations that may be made.

Examples

Oil pools in the Miocene sands in the Gulf Coast area, with few exceptions, have an active water drive. Two wells tested had productivity index declines as shown in Fig. 1, and did not have water drive. The wells are in the same pool and the tests were made shortly after completion. During the 30-hr. test on well A, the rate of production declined from 10 bbl. per hour to 6 bbl. per hour, and the bottom-hole pressure declined from 2510 lb. per sq. in. to 1470 lb. per sq. in. The rate of production from well B was constant at 12½ bbl. per hour during the 27-hr. test, but the bottom-hole pressure declined from 3980 to 3620 lb. per sq. in. Three years later the static pressure in well A had declined to one third of the original, and shortly thereafter it was put on artificial lift. Well B after 4 years had static pressure of one half the original, and was making 7 per cent water. The gas-oil ratio is three times the original, which is less than usual in wells having a similar declining productivity index. Other wells in the same area producing from sands of comparable thickness do not have a declining productivity index and are depleted by natural water flood, with little change in gas-oil ratio and no substantial decline in static bottom-hole pressure.

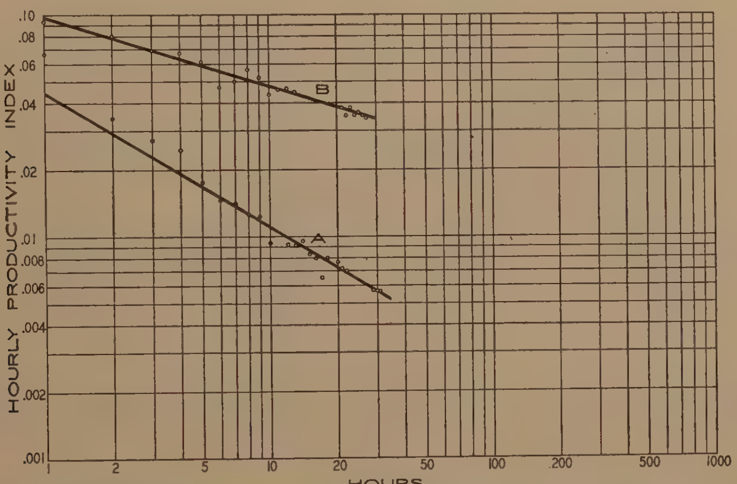

Fig. 1.—Declining productivity index of two Gulf Coast salt-dome wells, normally expected to be producing from a water-drive reservoir.

Fig. 2 presents the results of tests on a West Texas well. It shows the productivity index decline at varying production rates, and the usual persistence of the decline. Curve *A* shows the productivity index while the well was flowing 70 bbl. per hour. Curve *B* is a 550-hr. test with an initial production rate of 52 bbl. per hour and a final rate of 30 bbl. per hour. The divergence of the first few points was caused by reducing the size of the choke about 30 min. after the well began to produce. Another test of the well is shown by curve *C*, when it flowed at 11 bbl. per hour for 24 hr. without measurable change in the production rate. The curves also show a characteristic of this type of well to restore its productivity index when it is shut in. It illustrates the characteristic that is important when evaluating benefits of reconditioning that prevents the well from

producing for an extended period. If a well has a declining productivity index, benefits credited to the reworking of a well may actually be the result of productivity restoration.

Another example of productivity index restoration and consistency of rate of decline is shown by Fig. 3, which shows three tests at different rates of flow on successive days from a "Wilcox" sand well in Oklahoma. Approximately 16 hr. shut-in time between tests was not long

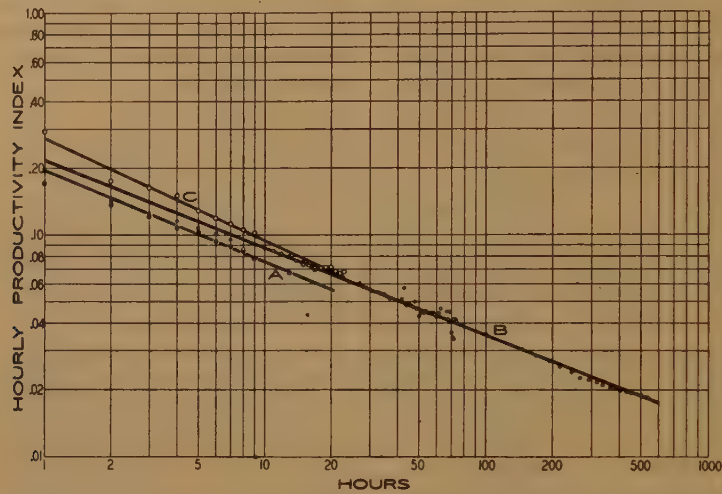

FIG. 2.—SAME RATE OF PRODUCTIVITY INDEX DECLINE AT DIFFERENT RATES OF PRODUCTION, AND CONTINUATION OF DECLINE ON A LONG TEST; RESTORATION OF PRODUCTIVITY INDEX DURING SHUT-IN OF WELL.

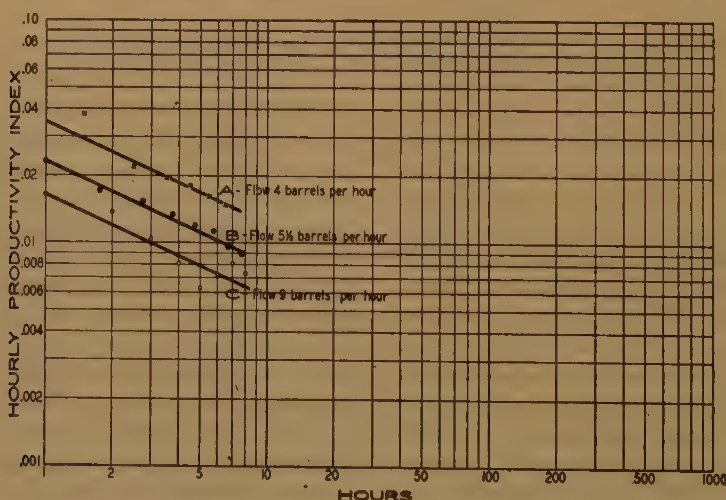

FIG. 3.—ORDOVICIAN "WILCOX" SAND WELL, SHOWING SAME RATE OF PRODUCTIVITY INDEX DECLINE AT DIFFERENT RATES OF PRODUCTION, RESTORATION OF PRODUCTIVITY INDEX DURING SHUT-IN OF WELL.

Note lower productivity index when well is not shut in long enough to build up static pressure.

enough to build up to maximum static pressure, and accounts for the initial productivity index being lower on each successive test. Rates of flow during the although average thickness. The recovery was quite disappointing.

The declining productivity index of a well producing in one of the major fields

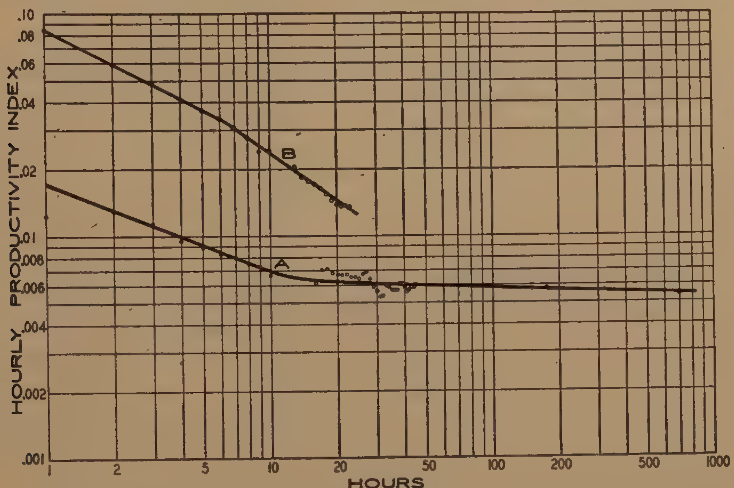

FIG. 4.—A CHANGE IN RATE OF PRODUCTIVITY INDEX DECLINE HAS BEEN FOUND IN A FEW WELLS SEVERAL HOURS AFTER THE TEST WAS STARTED.

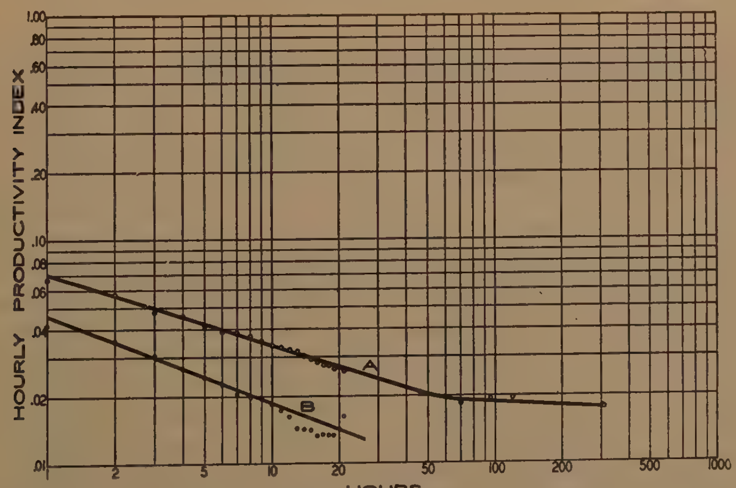

FIG. 5.—CURVE *B* IS CONTINUATION OF TEST SHOWN BY CURVE *A* AFTER THE SIZE OF CHOKE HAS BEEN INCREASED.

tests were 4, 5½ and 9 bbl. per hour. The "Wilcox" is the most widespread and consistent oil-producing sand in Oklahoma, but in this pool it had low permeability of New Mexico is shown in Fig. 4, curve *A*. The test illustrates a flattening of the curve that sometimes occurs. On this test the well was produced at an initial rate of 4 bbl.

per hour, and after 300 hr. had declined to $3\frac{1}{3}$ bbl. per hour. The bottom-hole pressure at the beginning of the test was 1345 lb. per sq. in. and had declined to 950 at the time of the break in the curve; then it declined to 720 lb. per sq. in. at the end of the test. This well was in an area where most wells had a low productivity index decline. Fig. 4, curve *B*, shows the results of a test in which the rate of productivity index decline increased. In the rare cases observed, this sharp change

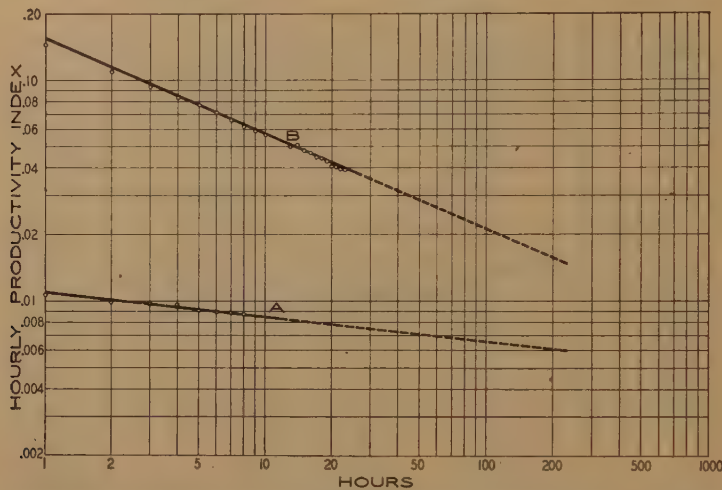

FIG. 6.—CURVE *A* SHOWS PRODUCTIVITY INDEX DECLINE BEFORE ACIDIZING AND CURVE *B* AFTER ACIDIZING.

Note larger productivity index, but higher rate of productivity index decline in curve *B*, indicating temporary benefit from acid.

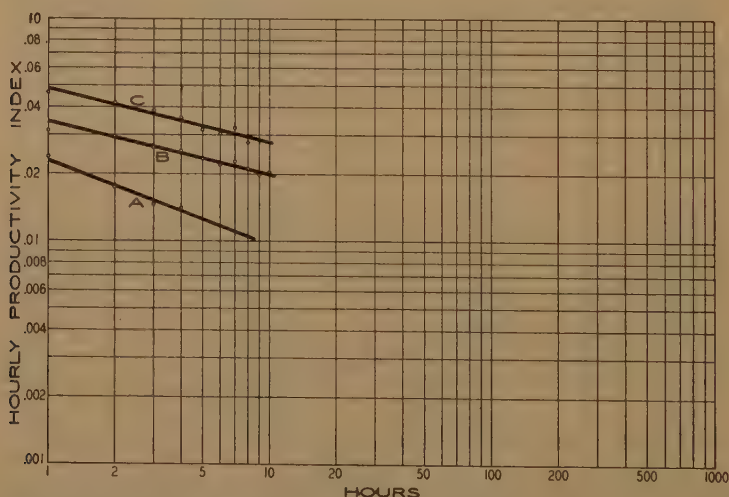

FIG. 7.—CURVE *A* BEFORE ACIDIZING, CURVE *B* AFTER ACIDIZING AND CURVE *C*, 19 MONTHS AFTER ACIDIZING.

Larger productivity index and lower rate of decline in curves *B* and *C* indicate permanent benefit from acid.

in slope has been accompanied by increasing gas-oil ratio and greater decline in production and in bottom-hole pressure. When the curve flattens, the apparent transition is a period of a few hours.

the test after acidizing shown by curve *B*. The convergence of these curves indicates that the increase in productivity is temporary and there is a question whether the ultimate recovery was increased.

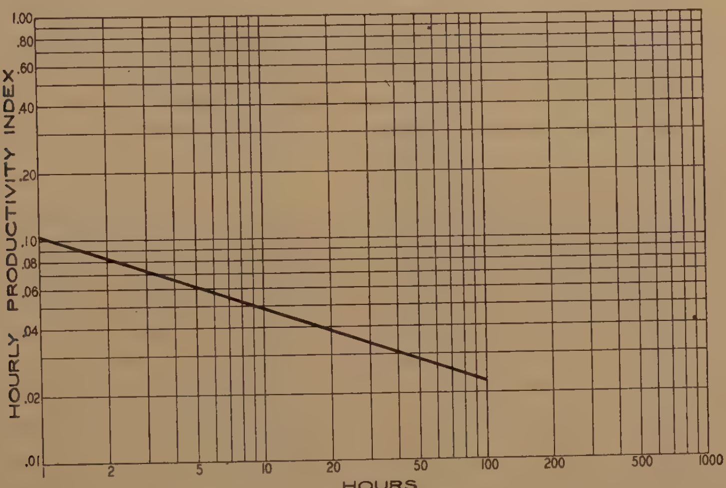

FIG. 8.—COMPOSITE PRODUCTIVITY INDEX DECLINE OF SEVERAL WELLS IN THE NORTH ST. LOUIS POOL, POTTAWATOMIE COUNTY, OKLAHOMA.

The curves in Fig. 5 show the result of changing the size of choke during the test. Curve *A* shows the decline in productivity index while the well was being produced at 4 bbl. per hour for 310 hr. Curve *B* is the productivity index curve by continuation of the test after the choke was increased to permit production at the rate of 16 bbl. per hour. It has been observed that a change in choke size to either increase or decrease the rate of flow will cause partial restoration of the productivity index.

The use of productivity index decline tests to evaluate the results of acidizing a well are shown in Fig. 6. The well produced 2½ bbl. per hour through a ¼-in. choke before acidizing. After treatment with acid, a test made through a choke of the same size gave a production of 5¾ bbl. per hour. The productivity index test before acidizing is shown by curve *A*, which is relatively flat as compared with

A well having beneficial results from acidizing is shown in Fig. 7. Productivity index tests on this well while producing through ⅜-in. choke at the rate of 12½ bbl. per hour before acidizing are shown by curve *A*, and at the rate of 19 bbl. per hour immediately after acidizing are shown by curve *B*. Curve *C* is a test made while producing 11 bbl. per hour through a ¼-in. choke on this well 19 months after acidizing, the additional improvement in productivity index possibly being due to further cleaning out of acid-water residue. The immediate effect of the acidizing is shown by the increase in numerical value of productivity index. The ultimate benefit is indicated by the lower rate of decline of the productivity index.

A group of 14 wells in the North St. Louis pool of Pottawatomie County, Oklahoma, had an appreciable productivity index decline, a composite of several tests being

shown in Fig. 8. The production history of that portion of the field is shown in Fig. 9. Production is from an oil-saturated section some 50 ft. thick in the Hunton limestone, found at a depth of 4500 ft. Wells were completed with flowing capacity ranging from 200 to 600 bbl. per day and gas-oil ratios were 1000 cu. ft. per barrel. Wells were drilled in diagonal corners of 40-acre tracts, giving a regular 20-acre spacing.

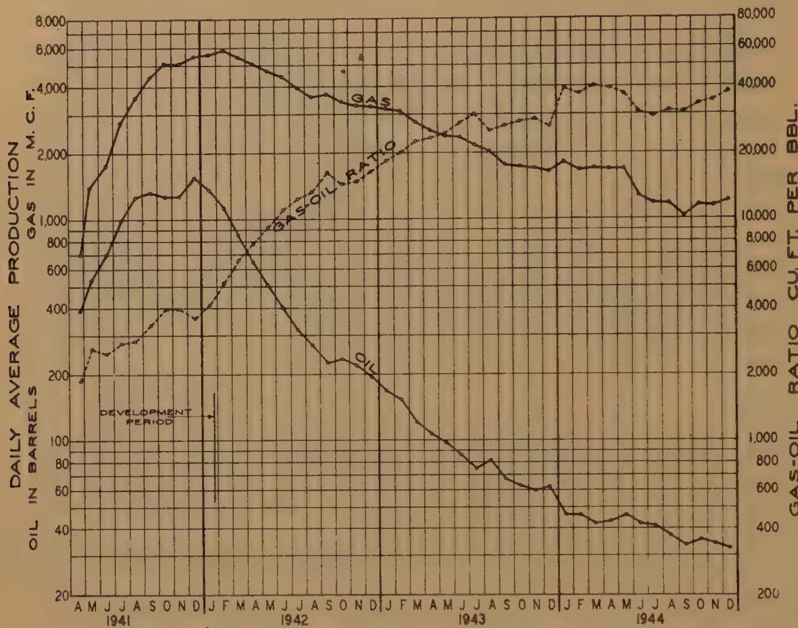

FIG. 9.—PRODUCTION OF OIL AND GAS, AND GAS-OIL RATIO OF 14 WELLS IN THE NORTH ST. LOUIS POOL, POTTAWATOMIE COUNTY, OKLAHOMA.

Rapid decline of oil production and rapid increase of gas-oil ratio were predicted because of declining productivity index found in first wells completed in the pool.

The productivity index test taken at the time of the completion of the first well gave an indication of the characteristics of the pool, which was confirmed by similar tests on the next two wells completed. Recoveries estimated after considering information from the tests were much lower than normally would be expected, based on the initial performance of the wells and thickness of oil-saturated lime. Most early estimates of ultimate recovery without knowledge of declining productivity index were 4000 bbl., or more, per acre. The field history to date shows that the ultimate recovery will be approximately 1900 bbl. per acre.

The high gas-oil ratio in this field is normal for wells with an appreciable productivity index decline. Efforts to improve the ratio were either without effect or had only temporary response. Shooting, acidizing, and selective zone production were of no benefit. Stop-cocking or intermittently producing wells has reduced the gas-oil ratio, but has been less effective than in many pools having a similar declining productivity index.

Rapid decline in rate of oil production, increasing and excessive gas-oil ratios, and production without water drive were anticipated early in the life of the field. These predictions based on the declining productivity index were of practical value in the selection of equipment and planning

operations for the field. A small electric generating plant, small pumping units driven by electric motors, and automatic time-pumping equipment were selected, all of a type that could be operated intermittently, and so arranged that a minimum of operating labor would be required. Considerable second-hand material, such as tubing and sucker rods, was used for the light pumping service predicted.

Summary

A summary of the experience thus far is that when a test of a few hours duration shows a definite declining productivity index, it is reasonably safe to predict that: (1) the rate of oil production will decline more rapidly than normally would be expected, (2) the gas-oil ratio usually will increase abnormally, (3) the amount of water ultimately produced will be negligible, if any, (4) productivity index will be restored by shutting the well in for a short time.

When such well performance is indicated, it follows that certain reservoir performance and operating practices may be anticipated: (1) the ultimate oil recovery will be lower than expected for a gas-drive reservoir, (2) wells will flow naturally to a lower reservoir pressure and to a lower rate of production, (3) there will be no active water drive, (4) acidizing, shooting, reworking can be better evaluated, (5) wells will produce currently and probably ultimately as much oil, and often more, when shut in from 10 to 30 per cent of the time, (6) smaller lifting equipment will be required and, (7) wells can be operated alternately.

It is significant that the basis of these important predictions is bottom-hole pressure tests that can be made immediately after completion of the wells.

Chapter III. Production

Introduction

By Winthrop P. Haynes,* Member A.I.M.E.

The symposium on production for the year 1944 includes more foreign papers than any one of the past three years, because of a partial relaxation of the censorship in many Western Hemisphere countries. The committee was not successful, however, in securing papers from Europe and the Near and Far East at this time, with the exception of Saudi Arabia and Bahrein.

Where possible, these papers include summaries upon production for the missing war years, so that we shall have no permanent gap in the records. At the close of the war, we hope again to publish the usual more complete form of report for all important oil-producing countries.

Excerpts from Circular to Authors

In order to facilitate interpretation of the data in this chapter, we print the following excerpts from the Circular to Authors.

The field is the unit in this tabulation. In cases of fields extending across State boundaries, such as Rodessa, it is suggested that each State author treat the section of the field in his State as a unit, and by a footnote indicate that the field extends into an adjacent State.

Each place in the table may represent one of three possibilities; either the proper entry is determinable and can be supplied by the author, or an approximate figure can be supplied which is the author's best guess and should be entered followed by an *x*, or it does not apply to the particular field and the space is left blank. Contributions of great value may be made by the author in many cases where entries are not subject to precise determination. In such cases the author should use his good judgment and make the best entry possible under the circumstances.

The entry of a zero is a positive declaration, and it is an important declaration where it is in order.

It is thought that the nearest whole numbers are sufficiently accurate for our purposes except as to percentage of sulphur in oil. If an author desires to report any other figures to tenths, he may do so.

The quantity of gas produced should include, where possible, gas sold or otherwise marketed, and gas blown into the air, burned as flares or otherwise wasted. Segregation of these figures would be interesting if the authors can make such segregation. In any event, the figures should represent as nearly as possible the total quantity of gas removed from the reservoir.

Under the columns on "Depth," the average depth to the top of the productive zones and to the bottom of the productive wells, when subtracted, should give the approximate thickness of the productive zone. For fields where this is not true because of unusually high dip or for some other reasons, it is suggested that the authors indicate in their text the approximate average thickness of the productive zone.

The net thickness of the producing formation should be the thickness of the producing zone, less the estimated amount to cover the portions of the zone that do not yield oil, such as dense shales, etc. It is recognized that for some fields the authors can only make rough guesses; in such cases, they should enter their best estimate followed by an *x*. Average production per acre-foot need not be reported as it can

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be calculated by those interested from the figures given.

In classifying wells as to producing methods, enter all wells that are not "flowing" in the column headed "Artificial Lift." If possible, add footnotes to indicate whether the lift is "pumping," "gas lift" or "air lift."

It is recognized that for many fields it would be very difficult to determine accurately the quantity of each gravity of oil produced. However, the approximate weighted average gravity that will be representative of the total production can be determined sufficiently accurately to constitute significant information.

Footnotes to Column Headings—Table 1

[a] All fields to be listed alphabetically and if by counties the latter also in alphabetical order. If the field is a gas field, or is primarily a gas-producing field, indicate by asterisk immediately after the name of the field, as, for example, Katy,* *Waller*.

[b,d] Total area in surface acres in the field proved for production.

[c] Total production in barrels of oil and/or distillate or condensate; and show by footnote, where possible, the amount of distillate or condensate production.

[e] Volume of gas produced from the field and not returned to the reservoir.

[f] Include all original completions, but exclude workovers and wells deepened or plugged back. *Abandoned* refers only to wells abandoned after having produced oil and/or gas and is not to include wells abandoned without having secured production.

[g] A well producing both oil and gas is classified as an oil well, unless it has been designated as a gas well by the State regulatory agency. Gas wells are wells producing gas only, wells producing condensate or distillate, and wells producing some oil but classified as gas wells by the State regulatory agency.

[h] Show type of operation as indicated by the following symbols: P, pressure maintenance; G, gas injection; W, water injection; C, cycling.

[i] Show weighted average gravity A.P.I. at 60°F. as oil is delivered to the pipe lines, and percentage of sulphur, if any, in the oil. Where oils from more than one stratum are commingled and delivered into the pipe line at a gravity of 26 to 26.9, show as 26°, etc.

[j] Show name of producing formation, and show its age by abbreviation as follows: Cam, Cambrian; Ord, Ordovician; Sil, Silurian; Dev, Devonian; Mis, Mississippian; MisL, Lower Mississippian; MisU, Upper Mississippian; Pen, Pennsylvanian; Per, Permian; Tri, Triassic; Jur, Jurassic; CreL, Lower Cretaceous; CreU, Upper Cretaceous; Eoc, Eocene; Olig, Oligocene; Mio, Miocene; Pli, Pliocene.

[k] Show character of formation by code letter as follows: A, anhydrite; C, chalk; Cg, conglomerate; Ch, chert; CR, cap rock; D, dolomite; Da, arkosic dolomite; Gw, granite wash; Sh, shale; L, limestone; LS, limestone, sandy; OL, oölitic limestone; S, sandstone.

[l] Figures represent ratio of pore space to total volume of net reservoir rock expressed in per cent. P indicates reservoir rock is of porous type, but ratio is not known by the author. Cav indicates that the reservoir rock is of cavernous type; and Fis, fissure type.

[m] Show actual depth to top of producing stratum. If producing zone is a series of interbedded sands and shales, and the sands are all productive or capable of producing, show the depth to top of top sand member.

[n] Show actual average thickness that is producing or known to be productive. If, for example, average thickness of productive zone above water level is 50 feet, show 50 feet, even though wells are completed in only upper 10 or 15 feet of zone.

[o] A, anticlinal; AF, anticlinal with faulting as important factor; Af, anticlinal with faulting as minor factor; AM, accumulation due to both anticlinal and monoclinal structure; D, dome; DS, salt dome; H, strata are horizontal or nearly horizontal; MC, monocline with accumulation due to change in character of stratum; MF, monocline-fault; MI, monocline with accumulation against igneous barrier; ML, monocline-lens; MU, monocline-unconformity; MP, monocline with accumulation due to sealing at outcrop by asphalt; N, nose; S, syncline; T, terrace; TF, terrace with faulting as important factor.

[p] Show name of deepest stratigraphic zone tested and total depth of well which tested such zone, whether it is deepest well in field or not.

x Correct entry not determinable.

Oil and Gas Development in Arkansas in 1944

By J. F. Gallie,* Member A.I.M.E.

South Arkansas

From the standpoint of exploration and new discoveries, South Arkansas had a discouraging year in 1944. In January there were 73 untested drilling blocks, and 60 additions were made during the year. Of the total, 65 were condemned by dry holes on or adjacent to them, while 5 proved productive. The latter resulted in the discovery of the Salem Church, Calhoun Wilks, and Strong fields, and the extension of the Village field to the southeast. The year ended with 63 untested blocks, 41 of which were scheduled for tests to the Smackover lime, the state's deepest oil-producing formation.

Geophysical activity in 1944 totaled 164 crew weeks, of which 110 were seismic, 43 gravity, and 11 radioactive (Fig. 1), in contrast with 674 crew weeks reported for 1943, of which 563 were seismic and 111 gravity. Five seismograph and two gravity crews were engaged in exploration in South Arkansas during January 1944, but only two seismograph crews were working there at the end of the year. In addition, exploratory core drills were used for a total of 38 weeks during the year.

The year's few discoveries, none of which is considered as having added appreciably to state reserves, were the meager results obtained in the drilling of 62 wildcat wells 2000 ft. or deeper. Of this total (a detail of which appears in Table 2), 42 were drilled to the Smackover lime or below. The average depth of the 62 wells was 5384 ft., as compared with 4992 ft. in the preceding year, while the average depth of the 42 wildcats in the lime was 5913 ft. in 1944.

Fig. 2 has been prepared to show all wells penetrating to the Reynolds oölitic lime. The 1944 dry holes are circled lightly, while discoveries are heavily circled and shown as producers. Smackover lime fields, producing from the Reynolds oölitic lime member, are indicated in black, and the locations of dry wildcat wells drilled prior to 1944 are also shown. Table 3 provides a listing of all Smackover lime wells drilled through the end of 1944.

Production for the year was slightly more than in 1943, totaling 29,282,747 bbl., as compared with 27,521,943 bbl. for the preceding year. The increase was 1,760,804 bbl., or 6.4 per cent, bringing production to a peak exceeded only in the 1923 to 1928 period of flush production from the older shallow fields, principally Smackover. The increase was largely attributable to additional development in the Dorcheat-Macedonia, Atlanta, Fouke, Stephens-Smart, Haynesville, and Village fields, little production deriving from 1944 discoveries. These six fields accounted for 100 of the 122 field wells drilled during the year. Annual and cumulative production for the producing life of the state are presented graphically in Fig. 3.

Fig. 6 has been prepared by the author to show the producing ages and present known productive limits of all fields in South Arkansas. Production data, as usual, are assembled in Table 2, and provide a further breakdown of producing formations in the individual fields.

Manuscript received at the office of the Institute May 14, 1945.

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TABLE 1.—*Oil and Gas Production in Arkansas*

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944		Oil		Gas
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned	Flowing	Artificial Lift	
	SOUTH ARKANSAS													
1	Atlanta,[1] *Columbia*	1938	2,000	4,980,842	1,165,178		6,819	1,644	38	11[4]	1	34	2	0
2	Cotton Valley	1943	80	46,146	28,494		20	12	2	1[4]	1	1	0	0
3	Reynolds	1938	2 000	4,934,696	1,136,684		6,799	1,632	36	11[4]	0	33	2	0
4	Big Creek,* *Columbia*	1939	160[8]	154,524	9,230		3,929	225	1	0	0	0	0	1
5	Bradley, *Lafayette*	1925	80	186,705	(Abd.)		*x*	0	6	0	0	0	0	0
6	Bragg (Camden), *Ouachita*	1934	10	37,848	(Abd. 1940)		*x*	0	1	0	0	0	0	0
7	Buckner, *Columbia, Lafayette*	1937	1,680	4,720,366	665,244		1,156	172	29	0	0	5	24	0
8	Calhoun, *Columbia*	1944	120	33,411	33,411		367	367	3	3	0	3	0	0
9	Champagnolle (Rainbow), *Union*	1927	2,030	15,662,195	234,627		*x*	*x*	252	1	3	0	69	0
10	Columbia,*[2] *Columbia*	1942	40[8]	9,529	0		215	0	1	0	0	0	0	0
11	Dorcheat-Macedonia,† *Columbia*	1939	7,200[8]	6,260,029	2,358,758		71,778	26,391	97[4]	28[4]	0	41[4]	0	85[4]
12	Cotton Valley	1942	7,200[8]	2,129,742	1,284,067		23,538	11,111	87[4]	26[4]	0	40[4]	0	57[4]
13	Reynolds	1939	5,600[8]	4,130,287	1,074,691		48,240	15,280	64[4]	13[4]	0	1[4]	0	59[4]
14	El Dorado, East, *Union*	1922	1,380	9,191,262	130,597		*x*	*x*	211	0	0	0	36	0
15	El Dorado, South, *Union*	1920	7,740	49,342,950	295,404		*x*	*x*	1,116	0	8	0	179	0
16	Falcon, *Nevada*	1938	10	*x*	(Abd.)		*x*	0	2	0	0	0	0	0
17	Fouke, *Miller*	1940	1,100	1,606,097	603,190		*x*	*x*	36	12	0	10	24	0
18	Garland City, *Miller*	1932	370	2,221,008	62,730		*x*	*x*	28	0	0	0	8	0
19	Hampton, *Calhoun*	1943	20	9,129	4,658		*x*	*x*	1	0	0	0	1	0
20	Haynesville Extension, *Columbia*	1942	2,500	746,227	548,630		565	463	29	19	0	28	1	0
21	Hibank, *Union*	1942	40	388	388		*x*	*x*	2	1	0	0	2	0
22	Hillsboro, *Union*	1930	1,200	341,756	85,875		*x*	*x*	33	1	0	0	17	0
23	Irma, *Nevada*	1921	2,166	7,594,726	149,266		*x*	*x*	150	0	0	0	68	1
24	Lawson, *Union*	1935	20	3,500*x*	(Abd.)		*x*	0	2	0	0	0	0	0
25	Lewisville (Stamps), *Lafayette*	1939	320	640,247	46,359		*x*	*x*	19	0	1	0	17	0
26	Lenz, *Miller*	1930	20	*x*	(Abd.)		*x*	0	2	0	0	0	0	0
27	Lisbon, *Union*	1925	2,640	6,925,845	51,135		*x*	*x*	356	0	3	0	132	0
28	Magnolia, *Columbia*	1938	4,200	36,306,841	5,591,254		34,064	5,698	117	1	1	103	10	0
29	Cotton Valley	1943	40	28,979	27,828		23	23	1	1	1	0	1	0
30	Reynolds	1938	4,200	36,277,862	5,563,426		34,041	5,675	116	0	0	103	9	0
31	McDonald, *Ouachita*	1929	75	117,085	(Abd.)		*x*	0	6	0	0	0	0	0
32	McDonald, New, *Ouachita*	1941	60	8,107	5,562		*x*	*x*	4	1	0	0	3	0
33	McKamie,* *Lafayette*	1940	2,720[8]	3,163,418	1,104,374		24,317	9,284	20	1	1	0	1	19
34	Cotton Valley	1942	40	33,204	5,339		8	1	1	0	1	0	0	0
35	Reynolds	1940	2,720[8]	3,130,214	1,099,035		24,309	9,283	19	1	0	0	0	19
36	Midway, *Lafayette*	1942	1,640	5,768,940	2,376,440		1,516	642	42	0	0	33	8	0
37	Mount Holly, *Union*	1941	880	664,293	312,092		2,722	890	12	3	3	9	3	0
38	Cotton Valley	1943	40	3,790	1,541		0	0	2	0	2	0	0	0
39	Reynolds	1941	880	660,503	310,551		2,722	890	10	3	1	9	3	0
40	Mount Holly, West, *Union*	1943	40	8,573	4,714		1	1	1	0	0	1	0	0
41	New London, *Union*	1942	760	877,567	456,010		420	206	19	0	2	5	12	0
42	Nick Springs, *Union*	1940	50	720,366	38,779		*x*	*x*	15	0	3	0	6	0
43	Hosston	1940	40	714,349	38,779		*x*	*x*	14	0	2	0	6	0
44	Cotton Valley	1943	10	6,017	(Abd. 1943)		*x*	0	1	0	1	0	0	0
45	Patton, *Lafayette*	1941	80	65,543	31,959		146	56	2	0	0	1	0	0
46	Rodessa Extension, *Miller*	1937	2,300	7,017,030	196,167		*x*	*x*	123	0	2	0	55	0
47	Rodessa Extension, North (Wisinger), *Miller*	1943	415[8]	14,357	13,354		439	439	3	2	0	0	0	3
48	Salem Church,* *Union*	1944	1,200[8]	6,445	6,445		245	245	2	2	0	0	0	2
49	Schuler, *Union*	1937	2,960	42,513,448	4,933,476		70,621	12,394	171	2	1	53	36	3

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Includes West Atlanta.
[2] Shut in pending utilization of gas.
[4] Including dual completions.
[8] Includes proved gas area.

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[f]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
						SOUTH ARKANSAS							
1												Smackover	8,356
2	3,085	x		41.5	.29	Cotton Valley, Jur	S	15	7,210	12	AL		
3	3,821	3,203		44	.49	Reynolds,[3] Jur	OL	15	8,207	30	A		
4	3,723	x		66	.05	Reynolds, Jur	OL	12.5	7,956	38	A	Smackover	7,999
5	x	x		26.3	.43	Buckrange, CreU	S	x	2,785	5	A	Paluxy	3,555
6	x	x		16.2	2.56	Nacatoch, CreU	S	25	1,356	13	ML	Hosston	2,500
7	3,195	2,381		32	1.87	Reynolds, Jur	OL	20	7,200	30	A	Smackover	7,444
8	3,450	x		56	x	Reynolds, Jur	OL		8,260	40	A	Smackover	8,312
9	x	x		22–34	1.4–2	Meakin, Graves, Blossom, Tokio, CreU; Hosston, CreL	S	x	2,780 3,340	15	AL	Eagle Mills	6,911
10	3,750	3,750		66.4	.14	Reynolds, Jur	OL	15	8,030	25	A	Smackover	8,150
11												Smackover	9,028
12	x	x		45–67	.02–.43	Cotton Valley, Jur	S	15	7,850	25	AL		
13	4,243	2,881		43–62	.13–.39	Reynolds, Jur	OL	15	8,831	83	A		
14	x	x		20.5	1.92	Nacatoch, CreU	S	25	2,170	10	AL	Cotton Valley	6,003
15	x	x		33	1.11	Nacatoch, CreU	S	25	2,100	20	TL	Smackover	7,820
16	x	x		14	3.28	Nacatoch, CreU	S	x	1,180	10	AF	Smackover	6,068
17	1,485	x		31.4	1.26	Paluxy, CreL	S	25	3,400	22	MF	Smackover	9,550
18	x	x		31.7	1.26	Paluxy, Rodessa, CreL	S	x	2,925 4,200	7	ML	Smackover	7,906
19	x	x		13.5	4.00	Meakin, CreU	S	25	2,514	24	AF	Smackover	4,420
20	2,344	1,752		39	.60	Pettet, CreL	L	18	5,402	12	A	Hosston	5,690
21	x	x		37.6	x	Nacatoch, CreU	S	x	2,075	5	MF	Smackover	7,465
22	x	x		23.7	x	Nacatoch, CreU	S	24	2,235	7	N	Hosston	3,615
23	x	x		14.1	2.70	Nacatoch, CreU	S	25	1,150	27	MF	Hosston	3,728
24	x	x		24	x	Meakin, CreU	S	x	2,667	8	A	Cotton Valley	4,583
25	1,365	x		17–43	.63	Tokio, CreU; Rodessa, CreL	S	17	3,350	10	MF	Smackover	7,420
26	x	x		29.5–47	x	Glen Rose, CreL	S	x	2,845–4,210	5	L	Smackover	7,310
27	x	x		34.0	1.08	Nacatoch, CreU	S	25	2,100	15	SL	Smackover	6,861
28												Smackover	7,824
29	x	x		42	x	Cotton Valley, Jur	S	15	5,870	10	AL		
30	3,465	2,878		38	.89	Reynolds, Jur	OL	16.8	7,350	100	A		
31	x	x		30	x	Glen Rose, CreL; Hosston, CreL	S	30	2,800	7	MF	Hosston	3,378
32	x	x		16.4	x	Nacatoch, CreU	S	x	1,590	6	MF	Smackover	6,264
33												Eagle Mills	9,980
34	2,831	x		43.5	.38	Cotton Valley, Jur	S	15	7,255	12	AL		
35	4,365	x		58.6	.24	Reynolds, Jur	OL	17	9,048	106	A		
36	2,920	2,659	PW	36 2	1.32	Reynolds, Jur	OL	26	6,340	75	A	Smackover	6,750
37												Smackover	7,373
38	x	x		42.5	.27	Cotton Valley, Jur	S	18	6,112	6	AL		
39	3,180	3,075		38	.77	Reynolds, Jur	OL	20	7,146	26	A		
40	x	x		41.7	x	Cotton Valley, Jur	S	x	5,896	12	A	Smackover	7,410
41				30.8	1.88	Cotton Valley, Jur	S	18	5,669	35	A	Smackover	6,100
42												Smackover	6,819
43	1,600	x		37	.95	Hosston, CreL	S	30	3,400	20	MLF		
44	x	x		36	x	Cotton Valley, Jur	S	23.2	6,790	3	MLF		
45	4,380	x		45.5	.60	Reynolds, Jur	OL	16	9,312	30	A	Smackover	9,503
46	2,800	x		39–45	.34	Rodessa, CreL	S	25	6,050	25	AF	Rodessa	6,514
47	x	x		54–75	x	Rodessa, CreL	S	25	5,860	20	A	Rodessa	6,997
48	3,135	3,135		71.5	x	Reynolds, Jur	OL	20	6,939	28	A	Smackover	7,090
49												Smackover	8,328

[3] Oölitic lime member of Smackover formation.

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e]: To End of 1944	Gas Production: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas
50	Cotton Valley	1937	640	1,208,408	597,072		2,144	900	20[7]	2	1	7	8	0
51	Morgan	1937	*x*	2,872,983	167,740		[5]	[5]	12[7]	0	0	0	12	0
52	Jones	1937	2,960	33,080,837	3,570,793		60,783	10,594	149[7]	0	0	37	10	3
53	Reynolds	1937	800	5,351,220	597,871		7,694	900	17[7]	0	0	9	6	0
54	Schuler, East, *Union*	1941	240	603,891	169,853		954	134	6	0	0	4	2	0
55	Smackover, *Ouachita, Union*	1922	29,500	402,619,543	4,261,605		*x*	*x*	3,761	0	24	0	1,573	0
56	Heavy	1922	*x*	345,598,927	3,646,371		*x*	*x*	*x*	0	*x*	0	*x*	0
57	Light	1922	*x*	56,704,672	581,151		*x*	*x*	*x*	0	*x*	0	*x*	0
58	Snow Hill	1936	300	315,944	34,083		*x*	*x*	6	0	1	0	2	0
59	Stephens, *Columbia, Ouachita, Nevada*		3,180	10,817,002	1,836,210		*x*	*x*	401	24	9	0	308	0
60	Shallow[6]	1922	3,180	7,255,230	173,393		*x*	*x*	295	4	9	0	211	0
61	Smart Area (Deep)	1941	2,500	3,561,772	1,662,817		*x*	*x*	106	20	0	0	97	0
62	Strong, *Union*	1944	40	354	354		*x*	*x*	1	1	0	1	0	0
63	Texarkana,[2] *Miller*	1942	160	33,300	11,518		1,015	371	1	0	0	0	0	0
64	Troy, *Nevada*	1936	1,000	3,052,514	346,986		*x*	*x*	59	5	0	0	48	2
65	Urbana, *Union*	1930	780	8,390,897	547,318		*x*	*x*	78	0	3	0	63	0
66	Village, *Columbia*	1938	800	2,580,684	571,869		9,587	1,317	19	6	0	19	0	0
67	Wilks, *Union*	1944	40	10,075	10,075		88	88	1	1	0	0	0	0
68	Wilmington, *Union*	1943	40	11,662	9,789		*x*	*x*	2	1	0	0	2	0
69	Woodley (Grimes), *Union*	1922	240	488,501	5,488		*x*	*x*	27	0	0	0	7	0
70	Total, South Arkansas			636,529,020	29,286,371		230,964	61,027	7,308	126	65	350	2,717	116
	NORTHWEST ARKANSAS													
71	Aetna, *Franklin*	1928				200	750	74	2	0	0			2
72	Alma, *Crawford*	1916				700	13,288	52	8	0	0			7
73		1916				*x*	4,553	24	3	0	0			3
74		1922				*x*	8,735	28	5	0	0			4
75	Alma East Extension, *Crawford*	1924				300	1,921	14	7	0	0			4
76		1924				*x*	1,271	11	4	0	0			2
77		1926				*x*	204	1	2	0	0			1
78		1926				*x*	446	2	1	0	0			1
79	Beverly, *Sebastian, Franklin*	1937				625	1,367	128	5	0	0			5
80	Clarksville, *Johnson*	1926				1,770	32,857	2,247	13	1	0			10
81						*x*	347	0	2	0	0			0
82						*x*	207	0	1	0	0			0
83						*x*	843	93	1	0	0			1
84						*x*	1,937	17	1	0	0			1
85						*x*	980	72	1	0	0			1
86						*x*	5,553	223	3	0	0			1
87						*x*	2,378	110	1	0	0			1
88						*x*	4,016	257	2	0	0			1
89						*x*	10,316	333	5	0	0			2
90						*x*	6,280	1,142	3	1	0			2
91	Coal Hill, *Johnson*	1930				200	425	24	2	0	0			2
92	Ewing, *Sebastian*	1936				650	481	42	4	0	0			4
93						*x*	248	42	*x*	0	0			4
94						*x*	233	0	*x*	0	0			0
95	Greenwood Junction, *Crawford*	1927				350	728	0	7	0	0			0
96	Kibler, *Crawford*	1915				2,500	24,899	101	40	0	0			15

[5] Included in Cotton Valley group.
[6] Includes East Stephens.
[7] Including recompletions.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
50	3,090	x		45.4	x	Cotton Valley, Jur	S	16	6,900	10	AL		
51	x	x		41–42	.54	Cotton Valley, Jur	S	16	5,500	15	AL		
52	3,520	1,449	GW	34.6	1.40	Cotton Valley, Jur	S	17.6	7,530	42	A		
53	3,550	x	G	38	.91	Reynolds, Jur	OL	20	7,600	26	A		
54	2,509	1,755		47	.36	Cotton Valley, Jur	S	25	5,580	14	A	Smackover	7,702
55											DT	Igneous	7,973
56	x	x		19 23	2.02 2.36	Nacatoch Meakin Graves Tokio } CreU	S	25	1,925 2,230 2,340 2,600	60			
57	x	x		27	2.24	Meakin, CreU	S	25	2,275	30			
58		x		36.2	1.08	Reynolds, Jur	OL	25	4,787	20	A		
59				12.6	2.87	Nacatoch, CreU	S		1,500			Smackover	6,387
60	x	x		30.6	1.60	Buckrange, CreU	S	25	2,100	6	TLf		
61	x	x		23 32	1.80	Tokio, CreU Glen Rose Hosston } CreL	S S, L	25	3,040	27	AF		
62	2,265	2,265		36.2	.956	Reynolds, Jur	OL	20	6,319	17	A	Smackover	6,382
63	3,418	3,307		70	.30	Reynolds, Jur	OL	14	7,348	51	A	Smackover	7,700
64	x	x		14.1 22	2.24 2.51	Nacatoch Tokio } CreU	S	25	1,224	20	MF	Eagle Mills	6,143
65	x	x		19–33	1.39	Nacatoch, CreU Hosston, CreL	S S	25	2,270 3,004	12	AL	Smackover	6,520
66	3,350	3,050		41	.80	Reynolds, Jur	OL	20	7,319	18	A	Smackover	7,603
67	x	x		50		Reynolds, Jur	OL	15.5	7,847	24	A	Smackover	7,944
68	x	x		16.8	x	Graves, CreL	S	25	2,768	16	A	Smackover	5,836
69	x	x		19.8	1.94	Nacatoch, CreU	S	20	2,200	12	Af	Hosston	4,006
70													
						NORTHWEST ARKANSAS							
71	640	150				Atoka, Pen	S	x	(1,675)	x	A	Atoka	1,678
72											A	Atoka	2,916
73	330	55				Atoka (shallow)	S	x	(2,065)	7			
74	425	22				(deep)	S	x	2,600	20			
75											A	Atoka	3,070
76	378	39				Atoka (deep)	S	x	2,400	20			
77	300	34				(shallow)	S	x	(1,879)	7			
78	425	110				(stray)	S	x	(2,433)	4			
79	440	277				Atoka, Pen	S	x	(2,586)	12		Atoka	2,709
80							S	11–17			AF	Arbuckle (Ord)	6,110
81	345	x				(Self)	S	x	1,075	10			
82	550	170				(Bynum)	S	x	1,990	8			
83	727	280				(Hudson No. 1 & No. 2)	S	x	2,213	52			
84	730	320				(Hudson No. 1 & Russell)	S	x	2,213	39			
85	690	336				(Houston)	S	x	2,440	11			
86	1,025	352				(Russell)	S	x	2,742	21			
87	785	320				(Patterson & Russell)			2,742	41			
88	1,180	385				(Qualls)	S	x	3,012	31			
89	1,225	295				(Kelly)	S	x	3,040	25			
90	1,275	505				(Cline)	S	14	3,400	30			
91	500	240				Atoka, Pen	S	x	1,960	x	A	Atoka	5,596
92											A	Atoka	2,850
93	275	236				Atoka (deep), Pen	S	x	x	15			
94	250	x				(shallow)	S	x	x	4			
95	210	50					S	x	(2,380)	7	A	Atoka	2,380
96											AF	Atoka	2,775

New Fields

Four new Smackover lime fields were discovered in South Arkansas during 1944. In the order of their discovery, these are the Calhoun field of Columbia County, and the Wilks, Salem Church, and Strong fields of Union County. In addition, two previously discovered shallow producing areas were put on production during the year—the New McDonald and Hibank areas, both producing from the Nacatoch formation. These six fields will be discussed more fully below.

Calhoun.—The Calhoun field, thus far limited to the north half of sec. 10, T. 18 S., R. 20 W., was discovered by the Tidewater Associated-Seaboard Oil Company's No. 1 L. H. Pearce well. The reflection seismograph prospect had previously been drilled by the Carter Oil Co. in 1940 in its No. 1 Longino et al., in the center of the northwest quarter of the southeast quarter of the same section, but this well entered the porosity approximately at the water level, and hence was dry and abandoned.

The discovery well, following several tests in the porous Reynolds oölitic lime member of the Smackover formation, was completed producing 34 bbl. of oil per day on a 6/64-in. choke, with a gas-oil ratio of 5480 to 1, through perforations at 8282 to 8287 ft. and open hole at 8290 to 8298 ft. Tubing pressure was 2250 lb., while reservoir pressure was gauged at 3450 lb. per sq. inch.

Two other wells were drilled prior to the end of the year. These were the Southwood Oil Company's No. 1 L. H. Pearce, 1320 ft. due east of the discovery well, and Tidewater-Seaboard's No. 1 L. A. Longino, the same distance due south of the discovery. The former, which was spudded April 15, entered the porosity at 7970 ft. subsea, 2 ft. lower than

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
97						x	x	98	x	0	0			14
98						x	x	3	x	0	0			1
99	Lavaca, *Sebastian*	1921				1,600	2,444	0	14	0	0			0
100		1921				x	328	0	5	0	0			0
101		1928				x	2,116	0	9	0	0			0
102	Mansfield, *Sebastian, Scott*	1902				x	3,240[8]	30[8]	12	0	0			2[8]
103	Massard Prairie, *Sebastian*	1904				x	33,869	199	89	0	0			47
104	Ozark, *Franklin*	1930				1,000	4,090	259	11	0	0			9
105		1930				x	1,741	176	6	0	0			6
106		1937				x	1,703	74	2	0	0			2
107		1938				x	646	9	3	0	0			1
108	Section 10, *Crawford*	1920				500	1,855	51	4	0	0			3
109	Shibley, *Crawford*	1926				500	2,024	56	6	0	0			6
110	(Northwest of fault)	1926				x	823	16	4	0	0			4
111	(Southeast of fault)	1927				x	1,201	40	2	0	0			2
112	Silex, *Pope, Johnson*	1942				160	1,116	327	2	0	0			2
113						x	x	x	1	0	0			1
114						x	x	x	2	0	0			1
115	Tates Island, *Pope*	1929				1,200	3,569	399	3	1	0			3
116	Vesta, *Franklin*	1932				800	2,109	125	9	0	0			9
117	White Oak, *Franklin*	1943				1,200	553	286	4	2	0			2
118						x	553	286	2	0	0			2
119						x	0	0	1	1	0			0
120						x	0	0	1	1	0			0
121	Williams, *Crawford*	1918				3,800	40,964	470	64	0	0			37
122						x	x	376		0	0			31
123						x	x	94		0	0			6
124	Total, Northwest Arkansas						172,549	4,884	306					169

[8] Does not include gas used in brick and glass manufacture at nearby plant.

the discovery well, and was completed Oct. 11, 1944, through perforations at 8279 to 8287 ft., making 72 bbl. of 65° gravity oil per day, gas-oil ratio 14,000 to 1, through 13/64-in. choke. The latter, while not spudded until July 21, was completed three days earlier than the Southwood well. Porosity was encountered at the same subsea depth. Initial test was 86 bbl. per day through 7/64-in. choke, gas-oil ratio 5000 to 1, in an open hole from 8307 to 8312 ft. Reserves for this new field, apparently already limited to the east and southeast, may be set tentatively at one million barrels pending further development.

Wilks.—The discovery well of the Wilks field, Atlantic's No. 1 C. H. Murphy, is located in the NW 1/4 SW 1/4, sec. 2, T. 18 S., R. 18 W., and lies less than a mile northwest of the large Schuler field. Total depth of the well was 7944 ft., and completion was finally effected through perforations at 7861 to 7863 ft. Through 3/16-in. choke, the well gauged 100 bbl. of 44° gravity oil and 150 bbl. of salt water per day. Gas-oil ratio, despite the completion near the water-level, was 22,000 to 1. Flowing pressure was 1600 lb. Stratigraphically, this well encountered the Reynolds lime porosity 200 ft. lower than Schuler field wells.

The single well drilled was completed Feb. 6, 1944, and went dead in November, prior to which time it had produced 10,075 bbl. of oil. Workover was under consideration at the end of the year and was attempted, without success, in April 1945. The well, which seems assured of making a gas well, has been purchased, and another attempt to recomplete it as an oil well will be made. If this is unsuccessful, it is hoped to make it a gas well. Future development hinges upon the outcome of tests shortly to be undertaken.

Salem Church.—The Carter Oil Company's No. 1 Wilson C-106, discovery well of the Salem Church field, was drilled upon a reflection seismograph high. Carter assembled the block, approximating 1000 acres and centering around sec. 33, T. 16 S., R. 18 W., in

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[f]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
97	265	46				Atoka (deep), Pen	S	x	2,285	15			
98	220	39				(shallow)	S	x	1,260	18			
99											A	Atoka	3,092
100	285	190				Atoka (shallow)	S	x	x	4			
101	280	220				(deep)	S	x	(1,775)	15			
102	x	x				(4 sands)	S	x	862–2,200	x	A	Atoka	2,977
103	x	x				(2 sands)	S	x	(2,260)	10	A	Atoka	2,502
104							S				A	Atoka	5,755
105	875	255				Atoka (deep)	S	x	3,759	18			
106	640	142				(Anderson)	S	x	(2,167)	12			
107	670	97				(shallow)	S	x	1,819	12			
108	265	104					S		2,437	15	AF	Atoka	2,596
109											AF	Atoka	2,596
110	237	31				Atoka (shallow), Pen	S	x	1,245	8			
111	194	105					S	x	(2,630)	8			
112							S				AF	Boone	4,120
113	975	{700}				(2500 ft.)	S	26	2,475	37			
114	995					(2800 ft.)	S	26	2,802	15			
115	550	312					S	x	1,032	30	AF	x	4,375
116	525	211					S				A	Atoka	2,900
117											AF	Atoka	3,029
118	595	546				(shallow)	S	20	1,325	20			
119	954	954				(deep)	S	x	2,645	20			
120	966	966					S	x	3,017	x			
121											AF	Atoka	
122	288	50				(deep)	S						
123	237	61				(shallow)							
124													

1943, and started drilling Apr. 25, 1944, in the center of the SW ¼ NW ¼ of that section. Completion date was June 27, 1944. The Smackover lime was topped at 6897 ft., while the main porosity was some 40 ft. deeper. The section penetrated is reproduced from the Schlumberger log in Fig. 4 to acquaint the outsider with the character of the Reynolds oölitic lime, producing member of the Smackover lime formation.

Casing (5½ in.) was set at 7090 ft., and the Reynolds oölitic lime member of the Smackover lime formation was perforated with 48 shots at 6985 to 6998 ft. Initial potential on the well was 1,968,000 cu. ft. of gas and 82 bbl. of 71.5° gravity condensate in 20 hr. through ½-in. tubing choke. Tubing pressure was 2500 lb. The initial reservoir pressure, estimated at 3135 lb. per sq. in. gauge, was subnormal, and this further bore out W. A. Bruce's conception of the Smackover limestone formation as a continuous porous aquifer,[1] withdrawals from any of the reservoirs of which would affect all.

Shows of oil and/or gas were also reported logged in the discovery well in the overlying Hosston and Cotton Valley series of interbedded sands and shales. However, none of these were held to be of commercial value, and no tests were made. The uppermost 40 ft. of the Smackover lime, as drilled and cored, was dense to very slightly porous, and granular to oölitic in nature. In the more porous and permeable zone encountered between 6937 and 7012 ft., porosity averages slightly over 20 per cent and permeability 500 millidarcys.

Prior to the end of the year, the McAlester Fuel Oil Co. completed its No. 1 Wilson McRae, in the NW¼ SE¼ SW¼, sec. 28, T. 16 S., R. 18 W., as a northwest offset to the discovery well. The Smackover lime was

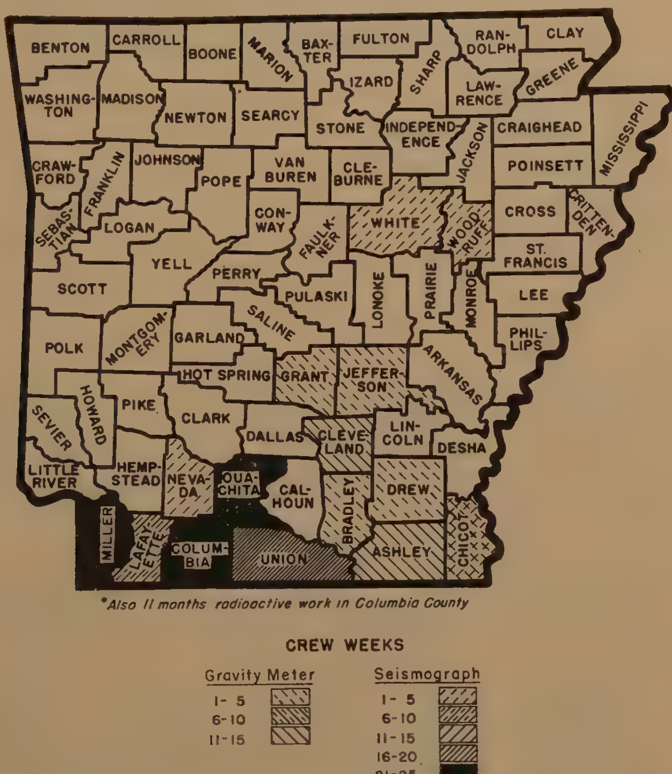

FIG. 1.—GEOPHYSICAL EXPLORATION IN ARKANSAS IN 1944.

[1] W. A. Bruce: *Trans.* A.I.M.E. (1944) 155, 88.

TABLE 2.—*Summary of Drilling Operations in Arkansas*

Important Wildcats Drilled in 1944

	County	Location Sec.	Location Twp.	Location Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke, Fractions of an Inch	Pressure, Lb. Per Sq. In.: Casing	Pressure, Lb. Per Sq. In.: Tubing	Remarks
	SOUTH ARKANSAS													
1	Ashley	29	17 S	4 W	3,006	Alluvium	Igneous	Lion Oil Refining Co.						Dry and abandoned
2		3	18 S	9 W	2,873	Terrace Deposits	Gas Rock	Union Producing Co.						Junked and abandoned
3		3	18 S	9 W	5,708	Terrace Deposits	Smackover	Union Producing Co.						Dry and abandoned
4		12	19 S	7 W	11,136	Alluvium	Eagle Mills	Union Producing Co.						Dry and abandoned
5		24	19 S	7 W	5,416	Terrace Deposits	Smackover	Union Producing Co.						Dry and abandoned
6	Calhoun	15	14 S	16 W	4,343	Alluvium	Smackover	John T. O'Neil						Dry and abandoned
7		3	14 S	16 W	3,682	Alluvium	Eagle Mills	Skelly Oil Co.						Dry and abandoned
8	Chicot	22	18 S	3 W	4,792	Alluvium	Smackover	Placid Oil Co.						Dry and abandoned
9		34	17 S	2 W	4,487	Terrace Deposits	Cotton Valley	Placid Oil Co.						Dry and abandoned
10		21	18 S	2 W	4,657	Terrace Deposits	Cotton Valley	Placid Oil Co.						Junked and abandoned
11	Clark	11	11 S	20 W	2,007	Alluvium	Eagle Mills	Coker & Grieves						Dry and abandoned
12	Columbia	5	17 S	20 W	7,750	Claiborne	Smackover	Crescent Drilling Co.						Dry and abandoned
13		16	17 S	21 W	8,168	Claiborne	Smackover	Frank & George Frankel						Dry and abandoned
14		9	16 S	20 W	6,950	Claiborne	Smackover	McAlester Fuel Co.						Dry and abandoned
15		25	16 S	19 W	7,286	Claiborne	Smackover	Northern Ordnance Inc.						Dry and abandoned
16		10	18 S	20 W	8,298	Claiborne	Smackover	Tidewater Asso.-Seaboard	242 (50° gr.)	1 1	12/64		2,250	Calhoun discovery
17		14	18 S	23 W	9,253	Alluvium	Smackover	G. H. Vaughn						Dry and abandoned
18		8	16 S	21 W	7,562	Claiborne	Smackover	G. H. Vaughn						Dry and abandoned
19	Hempstead	36	14 S	25 W	6,545	Alluvium	Smackover	Barnsdall Oil Co.						Dry and abandoned
20		2	14 S	26 W	5,258	Alluvium	Smackover	Barnsdall Oil Co.						Dry and abandoned
21		2	13 S	27 W	4,507	Alluvium	Eagle Mills	M. E. Davis						Dry and abandoned
22		23	13 S	24 W	4,524	Wilcox	Smackover	Royal Oil & Gas Corp.						Dry and abandoned
23	Lafayette	4	15 S	25 W	6,634	Alluvium	Smackover	Tidewater Asso.-Seaboard						Dry and abandoned
24	Lincoln	18	10 S	7 W	4,206	Jackson	Paleozoic	Curtis Kinard						Dry and abandoned
25	Miller	11	19 S	28 W	6,810	Claiborne	Lower Glen Rose	Arkla Oil Co.						Dry and abandoned
26		36	15 S	26 W	3,353	Alluvium	Paluxy	D. M. Fitzwater						Dry and abandoned
27		9	15 S	27 W	6,465	Alluvium	Smackover	Waldo Lumber Co.						Dry and abandoned
28	Nevada	35	14 S	21 W	5,467	Claiborne	Cotton Valley	DeKalb Agricultural Asso. Inc.						Dry and abandoned
29		17	13 S	21 W	4,463	Wilcox	Smackover	Barney Dunlap						Dry and abandoned
30		36	14 S	20 W	5,475	Claiborne	Smackover	Magnolia Petr. Co.						Dry and abandoned
31		14	14 S	22 W	5,619	Claiborne	Smackover	Placid Oil Co.						Dry and abandoned
32		3	14 S	20 W	5,500	Claiborne	Eagle Mills	Plymouth Oil Co.						Dry and abandoned
33		34	12 S	23 W	3,241	Wilcox	Igneous	Ryan Consolidated Petr. Corp.						Dry and abandoned
34		6	15 S	20 W	3,241	Claiborne	Cotton Valley	G. H. Vaughn						Dry and abandoned

35	Ouachita	33	12 S	18 W	3,281	Claiborne	Smackover	Garland Anthony						Dry and abandoned
36		30	15 S	19 W	6,387	Claiborne	Smackover	R. H. Crow, Tr.-Ohio Oil Co.						W. C. to Smackover in Stephens field. P. B. and produced from Buckrange sand
37		21	14 S	17 W	3,701	Claiborne	Cotton Valley	Lechner & Hill						Dry and abandoned
38		12	12 S	18 W	2,406	Wilcox	Smackover	Skelly Oil Co.						Dry and abandoned
39		9	14 S	17 W	4,351	Claiborne	Smackover	Skelly Oil Co.						Dry and abandoned
40		29	13 S	18 W	3,990	Claiborne	Eagle Mills	Skelly Oil Co.						Dry and abandoned
41	Prairie	10	1 N	5 W	3,210	Terrace Deposits	Paleozoic	Victory Development Co.						Dry and abandoned
42	Union	2	18 S	18 W	7,942	Claiborne	Smackover	Atlantic Refining Co.	100 (44° gr.)	2.2	3/16		1,600	Wilks discovery
43		33	16 S	18 W	7,090	Claiborne	Smackover	Carter Oil Co.	98 (71.5° gr.)	2.4	1/4		2,400	Salem Church discovery
44		26	18 S	15 W	2,517	Claiborne	Meakin	R. H. Crow						Dry and abandoned
45		17	17 S	11 W	5,550	Alluvium	Smackover	Kerlyn Oil Co.						Dry and abandoned
46		20	18 S	13 W	4,350	Claiborne	Cotton Valley	Kerlyn Oil Co.						Dry and abandoned
47		9	19 S	10 W	5,415	Alluvium	Smackover	Kerlyn Oil Co.						Dry and abandoned
48	Union	4	17 S	12 W	5,011	Claiborne	Cotton Valley	Curtis Kinard						Dry and abandoned
49		34	18 S	14 W	7,414	Claiborne	Smackover	Lion Oil Ref. Co.						Dry and abandoned
50		5	18 S	14 W	6,860	Claiborne	Smackover	Lion Oil Ref. Co.						Dry and abandoned
51		23	18 S	12 W	6,275	Claiborne	Smackover	Lion Oil Ref. Co.						Dry and abandoned
52		32	16 S	14 W	5,868	Claiborne	Smackover	J. R. Lockhart						Dry and abandoned
53		13	17 S	15 W	6,250	Claiborne	Smackover	Marine Oil Co.						Dry and abandoned
54		7	19 S	13 W	7,765	Claiborne	Smackover	Marine Oil Co.						Dry and abandoned
55		10	18 S	13 W	6,520	Claiborne	Smackover	Marine Oil Co.						Dry and abandoned
56		28	16 S	17 W	3,527	Claiborne	Travis Peak	C. E. Murdock						Dry and abandoned
57		30	18 S	12 W	5,010	Terrace Deposits	Cotton Valley	Phillips Petr. Co.						Dry and abandoned
58		16	16 S	18 W	6,950	Claiborne	Smackover	Root Petr. Co.						Dry and abandoned
59		27	18 S	12 W	6,382	Terrace Deposits	Smackover	Root Petr. Co.	92.5 (35.1° gr.)	.015	19/64		410	Strong discovery
60		22	17 S	13 W	4,204	Claiborne	Cotton Valley	Skelly Oil Co.						Dry and abandoned
61		13	16 S	17 W	2,900	Claiborne	Glen Rose	Southern Oil & Gas Co.						Dry and abandoned
62		30	17 S	14 W	4,003	Claiborne	Cotton Valley	Youngblood-Foree						Dry and abandoned
							Northwest Arkansas							
63	Franklin	13	10	27	1,380	Atoka	Atoka	Arkansas Western Gas Co.		33		595#		Discovery well White Oak Field
64	Franklin	16	8	27	2,375	Hartshorne	Atoka	Ozark Natural Gas Co.						Dry and abandoned
65	Franklin	21	9	27	4,301	Hartshorne	Atoka	Southern United Gas Co.						Dry and abandoned
66	Johnson	29	10	24	4,050	Hartshorne	Atoka	Arkansas Oklahoma Gas Co.						Dry and abandoned
67	Logan	33	8	22	4,748	Hartshorne	Atoka	Arkansas Louisiana Gas Co.						Dry and abandoned
68	Sebastian	3	6	31	3,350	Atoka	Atoka	Ozark Natural Gas Co.						Dry and abandoned
69	Van Buren	1	11	17	2,857	Atoka	Everton	Kerlyn Oil Co.						Dry and abandoned
70	Yell	19	7	21	4,705	Atoka	Atoka	Lion Oil Ref. Co.						Dry and abandoned

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944	17	12
Number of oil wells completed during 1944	110*	3
Number of gas wells completed during 1944	22*	1
Number of dry holes completed during 1944	17	65

* Includes 10 dual completions (oil and gas) at Dorcheat-Macedonia.

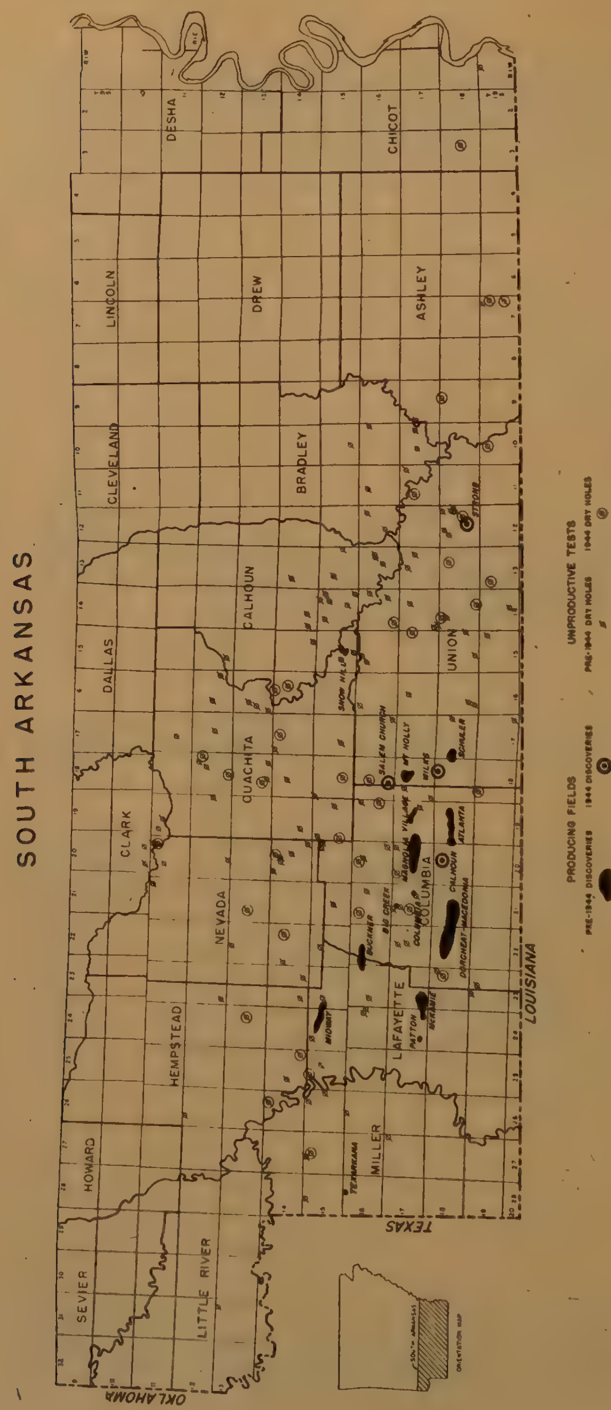

FIG. 2.—BASE MAP ON SMACKOVER LIME FORMATION, SOUTH ARKANSAS.

TABLE 3.—*Wildcat Wells in South Arkansas Penetrating the Smackover Lime*

Company and Owner	Well No.	Total Depth, Ft.	Description	Sec., Twp., Rge.
Ashley County				
Union Prod.-Crossett Lbr.	B-1	6,865	150'E of C S½ NE¼	2-19-7
Union Prod.-Crossett Lbr.	E-1	11,136	3370.6'S, 1258.3'E of NWc	12-19-7
Union Prod.-Crossett Lbr.	F-1	5,413	668'E, 576'N of SWc	24-19-7
Phillips-Godfrey	1	5,611	C S½ SW¼ NW¼	18-17-9
Union Prod.-Crossett Lbr.	2-D	5,708	753.3'S, 657.7'E of NWc	3-18-9
Bradley County				
Placid-Murphy	2	6,301	C SE SE	28-15-10
Placid-Southern Lbr. Co.	2	5,300	C NW SW	12-16-10
Amerada-Bradley Lbr. Co.	1	5,310	460'E, 660'N of SWc SE NE	14-17-10
Placid-Murphy	3	5,610	C SW SW	16-17-10
Phillips-Marsden	1	5,140	330'S, 662'W of NEc SW¼	9-16-11
Phillips-Murphy	1	5,627	C NW NW	12-17-11
Placid-Southern Lbr. Co.	1	5,045	C NE SE	11-16-12
Modisette (Phillips)-Brown	1	5,195	330'S, 660'W of NEc NW NE	28-16-12
Calhoun County				
Lockhart (Murdock)-Southern Kraft	1	5,010	C SE NW NW	17-14-13
British-Amer.—Freeman-Smith	1	4,790	C SE NE	17-15-13
Placid—Freeman-Smith	1	5,206	C NE SE	24-15-13
Placid—Freeman-Smith	3	6,927	C NE SE	14-16-13
Placid—Freeman-Smith	5	5,082	C NW SE	14-16-13
Placid—Southern Lbr. Co.	1	5,303	C SE SW	22-16-13
Placid—Furlow-Abbott	1	4,992	C SW SW	28-14-14
Placid—Sou. Lbr. & Int. Paper	1	4,450	C NW SE	30-14-14
Placid—Freeman-Smith	4	4,423	C NE NW	2-15-14
Placid—Freeman-Smith	8	4,699	C NW NE	8-15-14
Placid—Freeman-Smith	6	4,591	C SE SW	11-15-14
Placid—Freeman-Smith	2	4,615	C NW NW	12-15-14
Skelly—Calion Lbr. Co.	1	4,980	C NE SE	27-15-14
Barnett—Freeman-Smith	1	5,519	132'E, 145'N of SWc NE SW	36-15-14
Placid-Morgan Co.	1	5,150	C SE SW	12-16-14
Murdock—Freeman-Smith	1	2,551	200'N and W SEc SW SE	29-12-15
Placid-Gorth et al.	1	4,719	C NE SW	35-14-15
Proetz & Brown-Calion Lbr.	1	4,958	610'E, 300'N SWc SE SW	22-15-15
Skelly-Gaughn	1	3,682	818'S, 671'E NWc	3-14-16
O'Neil-Gaughn	1	4,343	C NE NE	15-14-16
Chicot County				
Hunt-Myers	1	6,403	C SE SE NE	3-19-1
Placid-Coleman	1	4,802	1980'W, 960'S NEc	22-18-3
Clark County				
Coker & Grieves-Williams	1	1,776	NE NE NE	7-11-19
McKenzie Oil-Eakin	1	1,700	325'N & E SWc SW NW	9-11-19
Wilson-Hamilton & Mathews	1	1,622	50'W of C SE NE	31-10-20
Whelen Oil-Burrows	2	2,351	150'N & E of SWc NE NE	35-10-20
Coker & Grieves-Sullivan	1	1,800	150'S & W of NEc NW SE	2-11-20
Coker & Grieves-Sparkman	1	2,007	C NE SW	11-11-20
Columbia County				
Phillips-Cox	1	7,410	C NE SE	8-17-18
Twin City-Hollingsworth	1	7,859	C NW SW	31-17-18
Barnsdall-El Dorado & Wesson	1	8,760	669.5'E, 660'N of SWc NW SW	5-19-18
Southwood-Medlock	1	6,666	C SE NE	12-16-19
Northern Ordnance-Wells	1	7,286	C NW NE	25-16-19
Carter-Phillips (*Village*)*	1	7,603	C SE NW	15-17-19
Forgotson-Dendy	1	7,768	C SW SW	24-17-19
Tide Water-Beene, J. T. (*Atlanta*)	1	8,332	C SE NW	15-18-19
T. W.-Young, A. O. (*W. Atlanta*)	1	8,356	C NE SE	18-18-19
Crow-Smart, J. F.	D-2	5,998	C NE NE SE	12-15-20
Crow-Smart, J. W.	1	6,030	C SW SW	12-15-20
McAlester-Luck, J. C.	1	6,950	C NE NE	9-16-20
McAlester (Southwood)-Staggs	1	6,935	C NW SW	10-16-20
Standard-Warnock	1	7,778	C NW NW	36-16-20
Phillips-Warnock	1	7,525	SW NW	1-17-20
Crescent-Cooley	1	7,750	C NW SE	5-17-20
Kerlyn-Barnett (*Magnolia*)	A-1	7,740	SE SW NE	14-17-20
Tide Water-Pearce (*Calhoun*)	1	8,298	C NE NW	10-18-20
Carter-Longino & Goode	1	8,405	C NW SE	10-18-20
Prock-Young	1	6,717	C NW SE	21-15-21
Vaughn-Jackson	1	7,502	C SE SW	8-16-21
Hayden-Runyan	1	7,659	C NW NW	14-16-21
Phillips-Askew	1	8,510	C NE NW	4-17-21
Standard-Petty Stave (*Big Creek*)	1	7,999	660'N, 735'W of SEc	4-17-21
Love-Stager	1	7,988	C SW NE	9-17-21
Frankel-Edwards	1	8,168	C SE SW	16-17-21
Lee-Pickler	1	8,125	C SW NE	23-17-21
Lee-Pickler (*Columbia*)	2	8,182	C NE SW	23-17-21
McAlester-Franks (*L. Macedonia*)	1	8,690	C SE SE	16-18-21

* Discovery well.

TABLE 3.—(*Continued*)

Company and Owner	Well No.	Total Depth, Ft.	Description	Sec., Twp., Rge.
Columbia County (*Cont.*)				
Carter-McKean, J. P. (*Buckner*)	1	7,309	C SW SW	8-16-22
Lion-Robertson	1	8,306	C NW NW	10-17-22
Sinclair Prairie-Souter	1	8,590	C NE SW	15-17-22
Atlantic-Pinewood (*Dorcheat*)	A-1	8,998	C NE NE	16-18-22
Gulf-Lewis	1	9,045	2030'S, 1980'W of NEc	12-18-23
Vaughn-Bodcaw	1	9,253	C NW NE	14-18-23
Northern Ord.-Waggoner	1	10,600	C NW NE	10-19-23
Hempstead County				
Stewart-Fee	1	3,031	350'N, 400'W of SEc NE NE	31-12-23
Hygrade Prod.-Copeland	1	6,403	C NW NW	32-14-23
Royal-McWilliams-Stanford	1	4,524	1981.5'W, 660'N of SEc NE NW	23-13-24
Barnsdall-Shultz	1	6,101	C SW NE	20-14-25
Barnsdall and Tide Water—Brunson	1	6,545	C NW NW	36-14-25
Easton-LaGrone	1	3,511	C NE NE	5-12-26
Barnsdall-Cox	1	5,412	660'S, 333.5'E of NWc NE SW	2-14-26
Lafayette County				
Frankel-Bodcaw	1	6,598	C SE NW	17-15-23
Erwin & Leach-Bodcaw	3	7,720	C NW NW NW	20-16-23
Atlantic-Bodcaw (*McKamie*)	1	9,221	C NE SW	29-17-23
McAlester-Jeffus	1	10,477	C NE NW	4-19-23
Barnsdall-Gunter	1	6,561	100'E of C SW SE	5-15-24
Barnsdall-Bond, Edgar (*Midway*)	1	6,536	C NW SW	11-15-24
Ohio-Garner	1	7,573	C NW SW	13-16-24
Shell & Ohio-Warren	1	7,284	C SE SE	13-16-24
Tide Water-Moore (*Patton*)	1	9,492	C SW SE	29-17-24
Tide Water-Landis	1	6,634	C SW NE	4-15-25
Mid-Continent-Russell	1	7,274	C NE NE	15-15-25
Little River County				
Grote-Allen	1	3,410	300'S & W of NEc of Sec.	2-13-31
Miller County				
T. W.-Seaboard-Sutton	1	6,685	380'W, 328.4'S of NEc NW SW	2-15-26
Moore-Dale	3	7,310	691'N, 455'W of Center	24-15-26
Magnolia-Oliver	9	7,906	C NE NE	4-16-26
Barnsdall-Grace Unit	1	6,695	C SE NW	4-15-27
Waldo (Anthony)-Grace	1	6,465	C NE NE	9-15-27
Carter-Sturgis	1	9,550	C NW SE	1-17-27
Sylvestre and Wadley-Mann	1	6,510	C SE NW	4-15-28
Carter-Orr (*Texarkana*)	1	7,700	C SE SW	3-16-28
Nevada County				
Lokey-Shepard-Purifoy	1	2,220	C NE NE NE	17-11-20
Hunt and Ark. Fuel-Kirk	1	4,037	C SW SE	33-12-20
Plymouth-Tompkins	1	6,500	660'N, 1970'W of SEc	3-14-20
Plymouth-Groves	1	5,268	C SE SW	5-14-20
Benedum-Trees—Block	1	5,394	C NE NE SE	9-14-20
Benedum-Trees—Grove	1	6,144	170'N of C N½ SE NW	10-14-20
Plymouth-Grove	2	5,577	C SE NE	21-14-20
Magnolia-Lester	A-1	5,475	C NE SW	36-14-20
Coker and Grieves-Jones	1	1,300	50'W, 150'S of NEc SE NE	2-11-21
Dunlap-Hart	1	4,463	C SE SW	17-13-21
Wakefield-Sanders, Rouse Unit	1	4,050	100'S of C SE NW	4-13-22
Placid-Silvey	1	5,610	C SW SE	14-14-22
Placid-Bodcaw Lbr. Co.	1	7,180	C SE NW	18-14-22
Texas-Canadian-Stocks	1	6,068	330'S, 380'W of NEc SW SE	9-15-22
Hunt-Stamps Land Co.	1	6,162	C NW NW	35-14-23
Ouachita County				
Lion-Levy	1	5,350	660'N, 330'E of SWc	21-15-15
Phillips-Reynolds, J. D. (*Snow Hill*)	1	4,926	330'N of S Line, 330'W of E Line of NW¼	27-15-15
Phillips-Joyce, Betty	23		706'W, 520'S NEc	33-15-15
Whitaker-Simon Howard	1	2,503	600'E, 150'N of SWc NW NE	20-12-16
Small, et al-Eagle Lbr. Co.	2	2,693	SW NW NW	25-12-16
Magale-Daniel and Parker	1	3,601	C NE SW	17-13-16
Danciger-Huddleston	1	3,515	C NE SE	19-13-16
Dekalb-Berg	1	4,073	C SW NW	31-13-16
Pure Oil-Moline Lbr. Co.	1	2,885	660'E, 300'N of SWc	21-11-17
Standard-Moline Lbr. Co.	1	2,597	300'E, 120'N SEc NE SW	22-12-17
Carnes-Berg	1	4,215	C SW NE	6-14-17
Skelly-Pate	1	4,351	C SE SW NE	9-14-17
Lion-Annie	1	6,093	C SE NE	29-15-17
Carnes-Camden Coal and Clay	1	3,200	430'E, 480'N of SWc SW NE	11-12-18
Skelly-Camden Coal and Clay	1	2,406	C SE SW	12-12-18
Straughan Pet.-Garnett	1	3,200	300'N & W Center	15-12-18
Anthony-Shankle	1	3,280	C SW SE SE	33-12-18
Skelly-Russell	1	3,990	C NE SE	29-13-18
Tide Water-Graves Est.	1	4,501	C NW SE NW	33-13-18

topped at 6960 ft. and the main porosity at 7000 ft. Analysis of tests and electric logs of the two wells permitted establishment of the oil-water contact at minus 6785 ft., or just over 50 ft. below the top of the main porosity in the discovery well. At the end of the year a third well, the Root Petroleum Company's No. 1 M. B. Manning, in the NW¼ SE¼ SE¼, sec. 29, T. 16 S., R. 18 W., one-half mile due west of the McAlester well, was drilling below 6900 ft. This well was to delimit the field on the northwest, as it entered the Reynolds lime below the oil-water contact and was abandoned as dry on Jan. 12, 1945.

Upon the basis of subsurface information available from these three wells, the productive area has been set at 1200 acres and the average effective producing thickness at 28 ft. Reserves have been conservatively set at 1 to 2 million barrels of condensate and 50 billion cu. ft. of gas.

Strong.—The Strong field, Union County, was discovered by the Root Petroleum Company's No. 1 Union Sawmill well, in the NW¼ NW¼, sec. 27, T. 18 S., R. 12 W. Location was staked upon subsurface geology, although a geophysical high was known to exist in the vicinity. Spudded Sept. 14, 1944, the well was completed October 27, swabbing 75 bbl. of 35.1° gravity oil per day and 15,000 cu. ft. of gas through perforations at 6319 to 6329 ft. Bottom-hole pressure was gauged at 2775 lb.

TABLE 3.—(*Continued*)

Company and Owner	Well No.	Total Depth, Ft.	Description	Sec., Twp., Rge.
Ouachita County (Cont.)				
Carnes-Rath & Cartier, Inc.	1	4,210	C NW SE	35-13-18
McAlester-Walker	1	4,573	C NE SW NW	16-14-18
Arkansas Fuel-McGaughy	1	5,326	680'S, 895'E of NWc	6-15-18
Vaughn-Haltom	1	6,264	C NE NE SE	28-15-18
Dickson-Benton	1	3,350	600'N, 600'E NWc SE	24-12-19
Vaughn-*Reynolds-Berg*	1	6,017	C SE SW	6-15-19
Deep Rock-Wesson	1	6,053	510'S, 660'W of NEc SE NE	23-15-19
Crow-Yarborough	1	6,387	C NW NW	30-15-19
Union County				
Kerlyn-Crossett	1	2,415	C SW SW NW	9-19-10
Kerlyn-Saw	1	5,560	C NW SW NE	17-17-11
Wheless & Marine-Union Saw Mill	1	6,286	C SW NW	1-18-12
Amerada-Turbeville	1	6,290	C SE SW	4-18-12
Modisett-Union Saw Mill	1	6,533	C SW NE	8-18-12
Lion-Sawmill	1	6,275	C NE NE SW	23-18-12
Root-Union Saw Mill (*Strong*)	1	6,382	C NW NW	27-18-12
Kerlyn-Union Saw Mill	1	5,835	C NW SE NE	9-17-13
Lion-Union	1	5,900	C NE SE NE	14-17-13
Marine-Thompson	B-1	6,250	C SE SE NE	10-18-13
Marine-Bank	1	7,765	C SE SE	7-19-13
Anthony-Giles	1	5,785	C NE SE	26-16-14
Lockhart-Armor	1	5,868	550'N, 330W SEc SW NW	32-16-14
Hunt-Gregory	15	6,911	C SW SE SE	10-17-14
Delta-Grace	1	6,819	C SE SE	31-17-14
Fohs, Pilgrim, Root-Grace	1	6,710	667.7'E, 562.4'N of SWc NW SE	31-17-14
Fohs and Pilgrim-Craig et al.	1	6,905	C SE NE	5-18-14
Lion-Nick	1	6,860	C NE NE	5-18-14
Lion-Mill	1	7,410	C NW SE	34-18-14
Oliphant-Union Saw Mill	1	7,950	668'E, 658'S of NWc NW SW	22-19-14
Lion-Hayes	A-9	7,255	242'S, 246'W of NEc SW NE	4-16-15
Murphy and Head-Murphy	1	5,728	C SE SW SE	8-16-15
Marine-Ezzell	1	6,253	665'S, 110'E of NWc NE NE	13-17-15
Crescent-Root	1	7,465	C NE NE	25-18-15
Murphy-Cates	C-1	7,718	670'E, 765'N of SWc NW SW	33-18-15
Carter-Foyil	1	7,909	790'S, 660'E of NWc	12-19-15
Gulf-Werner	49	7,973	4620'N, 60'E of SWc	5-16-16
Bradham-Slaughter	1	6,821	430'N & W of Sec.	9-17-16
Standard-Zimmerman	1	8,020	C SE SE	29-18-16
Delta-Pickering	1	7,970	664'S, 659'W of NEc SE NW	32-18-16
Lion-LeCroy	1	6,500	C SE NW	56-16-17
Crescent-Burns	1	7,701	100'E of C of NE SW	13-18-17
Lion-Morgan (*Schuler*)	A-1	7,683	330'S, 330'W of NEc NW NE	18-18-17
Barnsdall-Cameron	1	9,069	C SW NW	36-19-17
Root-McRae	1	6,950	C SW SE SW NE	16-16-18
Carter-Wilson (*Salem Church*)	1	7,091	660'N, 665'E of SWc SW NW	33-16-18
Atlantic-E. Davis (*Mt. Holly*)	1	7,373	C NE NW	15-17-18
Atlantic-Murphy (*Wilks*)	1	7,943	C NW SW	2-18-18

at 6207 ft. Seventeen feet of porous saturated oölitic lime were logged.

Although the well was completed in October, it was reworked in December and again in January 1945. Production prior to the end of the year was negligible, but when completed early in January and acidized with 1000 gal., the well flowed 90 to 100 bbl. of oil per day on 19/64-in. choke through perforations at 6319 to 6327 ft. An offset location on the 40 acres to the south was staked by the same company toward the end of March 1945, in its Union Sawmill No. 2, SW¼ NW¼, sec. 27, T. 18 S., R. 12 W. As the discovery well was presumably an edge well, further development will be required before any estimate of the field's magnitude and worth may be made.

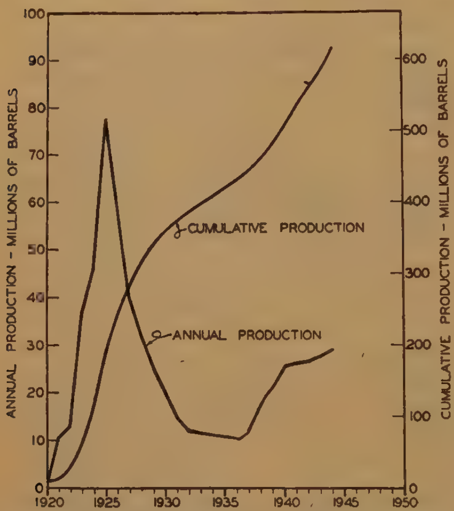

FIG. 3.—PRODUCTION OF OIL IN ARKANSAS FROM 1920 TO 1944.

New McDonald.—The New McDonald area of Ouachita County was proved productive of gas in the Nacatoch formation in November 1939, by Lee Bergman's No. 1 Cook well, and of oil in November 1941, by the same party's No. 3 Cook (No. 2 was a dry hole). Completion test on the latter well was 50 bbl. of low-gravity oil and 150 bbl. of salt water per day. All wells were drilled in the S½ NW¼ SW¼, sec. 27, T. 15 S., R. 18 W. The third producing well drilled in the area was S. A. Kinard et al.'s No. 1 Cook Estate, NW¼ NE¼ SW¼, sec. 27, and completed in January 1944. The three wells produced 5562 bbl. of oil from the field during the year.

On June 19, 1944, G. H. Vaughn spudded the No. 1 J. F. Haltom well, NE¼ NE¼ SE¼, sec. 28, and drilled it to the Smackover lime. At the end of the year tests were continuing in various sands encountered in the process of drilling, but it became necessary to abandon the well temporarily because of high water. Location was made for a second well in the same property in the NW¼ NE¼ SE¼, but it has not yet (April 1945) been spudded. Further development is expected during 1945, but no prediction may yet be ventured regarding the size of the field, which lies 2 miles west of the abandoned McDonald field.

Hibank.—The Hibank area received a Smackover lime test in 1942, when the Crescent Drilling Co. drilled its No. 1 Root Petroleum Co., NE¼ NE¼, Sec. 25, T. 18 S., R. 15 W. The well was abandoned as dry on Sept. 26 of that year, but Root took it over in the following month and set casing to the Nacatoch formation. In October 1943, L. B. Manley began drilling the No. 1 J. C. Wood well in the NE¼ SW¼ SW¼, sec. 25. In April 1944, this well swabbed an estimated 7 to 10 bbl. of oil per day from the Nacatoch, but the well was abandoned as noncommercial on May 12.

In October, however, both this well and the Root well were taken over by R. H. Crow, and pumping units were installed at about the same time drilling began on the R. H. Crow No. 1 Randolph Smith, NE¼ NE¼ NE¼, sec. 26, T. 18 S., R. 15 W. While this well was designated as a Nacatoch test, it was actually carried to the Meakin, nearly 400 ft. deeper, following coring of the Nacatoch, which proved marly. This well was shut down at the first of the year because ot high water, and has not yet been given a thorough test.

Although the two producing wells are almost level and are on a fairly extensive high, the character of the reservoir sands indicates that the area is of very questionable value. To the end of the year, only 388 bbl. of oil had been hauled out by truck from the two pumping wells.

Extensions

More than half a dozen fields in the state were extended in varying degree

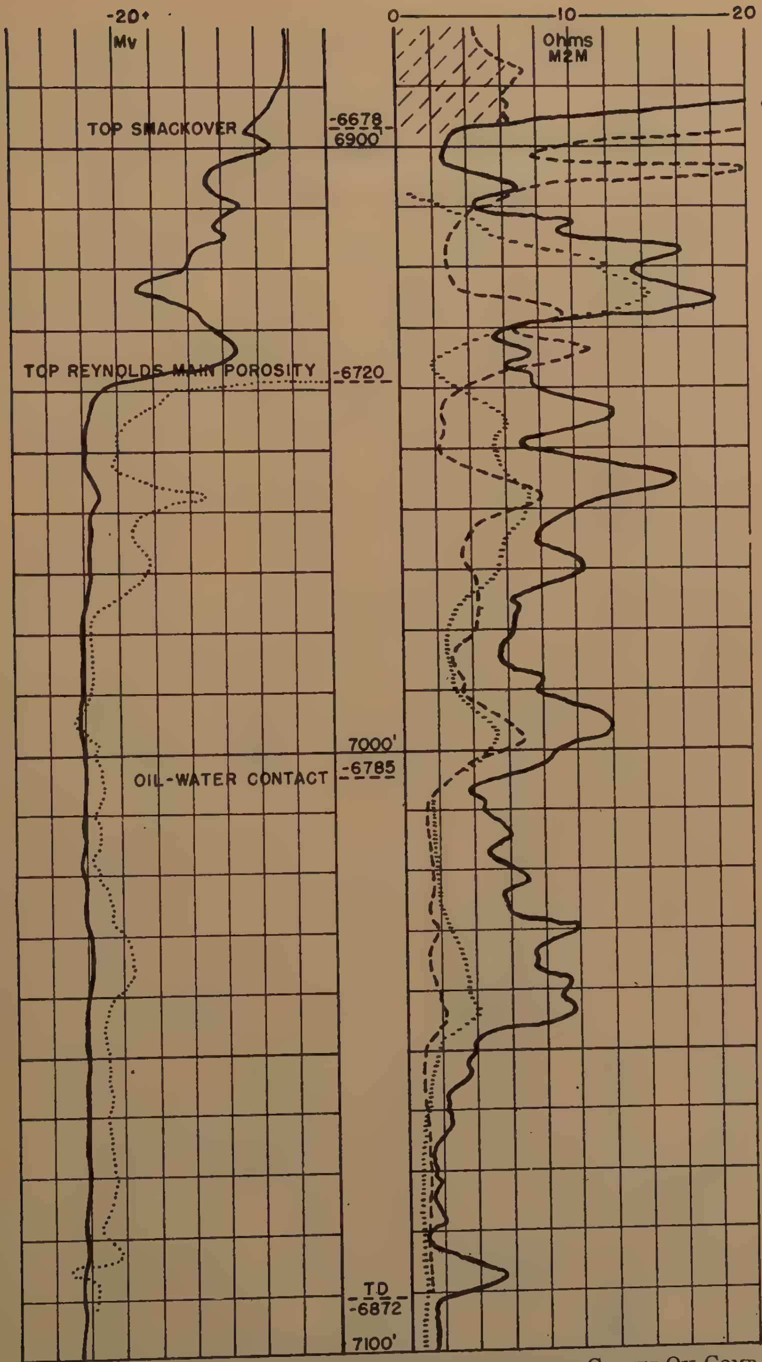

FIG. 4.—SMACKOVER LIME SECTION PENETRATED BY DISCOVERY WELL, CARTER OIL COMPANY'S NO. 1 G. F. WILSON C-106, SALEM CHURCH FIELD, COLUMBIA COUNTY, ARKANSAS.

in the course of the year's drilling. Most noteworthy of these were in the Fouke, Haynesville, Village, Atlanta, Dorcheat-Macedonia, and Stephens-Smart fields, which will be discussed in that order.

narrow fault-line field was pierced in Carter's No. 1 Weeks well, SE¼ NE¼ SW¼, sec. 32. Thus far production is limited to sands in the Paluxy formation. Reserves estimated at 1½ million bbl. have been added by this past year's development.

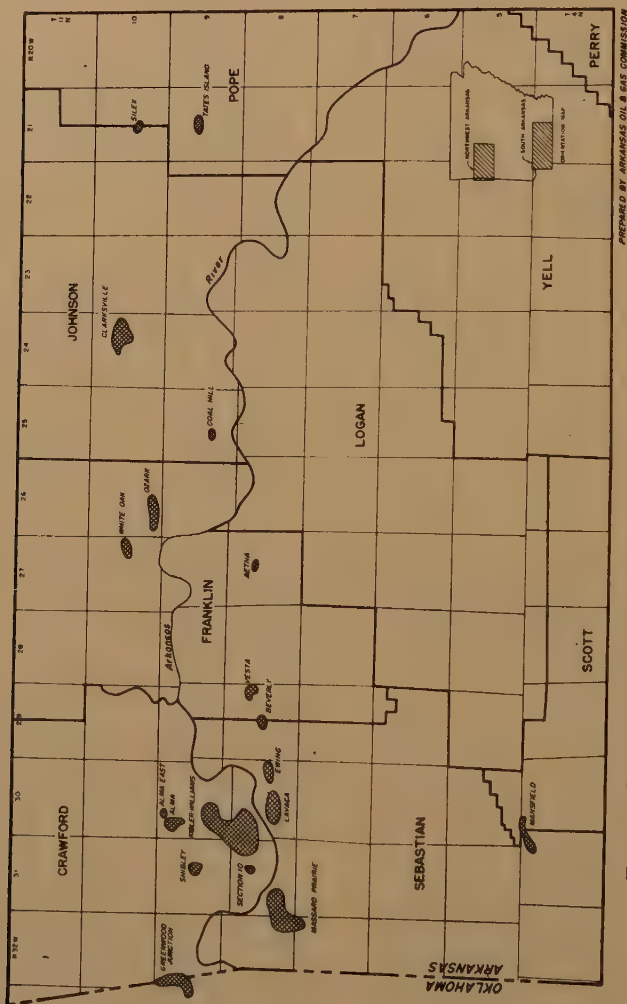

Fig. 5.—Gas fields, Northwest Arkansas. All of Pennsylvanian age.

Fouke.—The Fouke field of Miller County, although discovered in 1940, has undergone a third of its development in the past year, 12 producing wells having been drilled in that period. The field was extended northeastward in secs. 31, 32, and 33, T. 16 S., R. 26 W., and also one location southwest in sec. 11, T. 17 S., R. 27 W. Maximum effective section for the

Haynesville.—The Haynesville field, which produces from the Upper and Lower Pettet, underwent extensive development in Arkansas during 1944 following its earlier extension into the state from Louisiana. Nineteen producing wells were drilled and completed prior to the end of the year on unitized 80-acre locations. The productive sections encountered varied

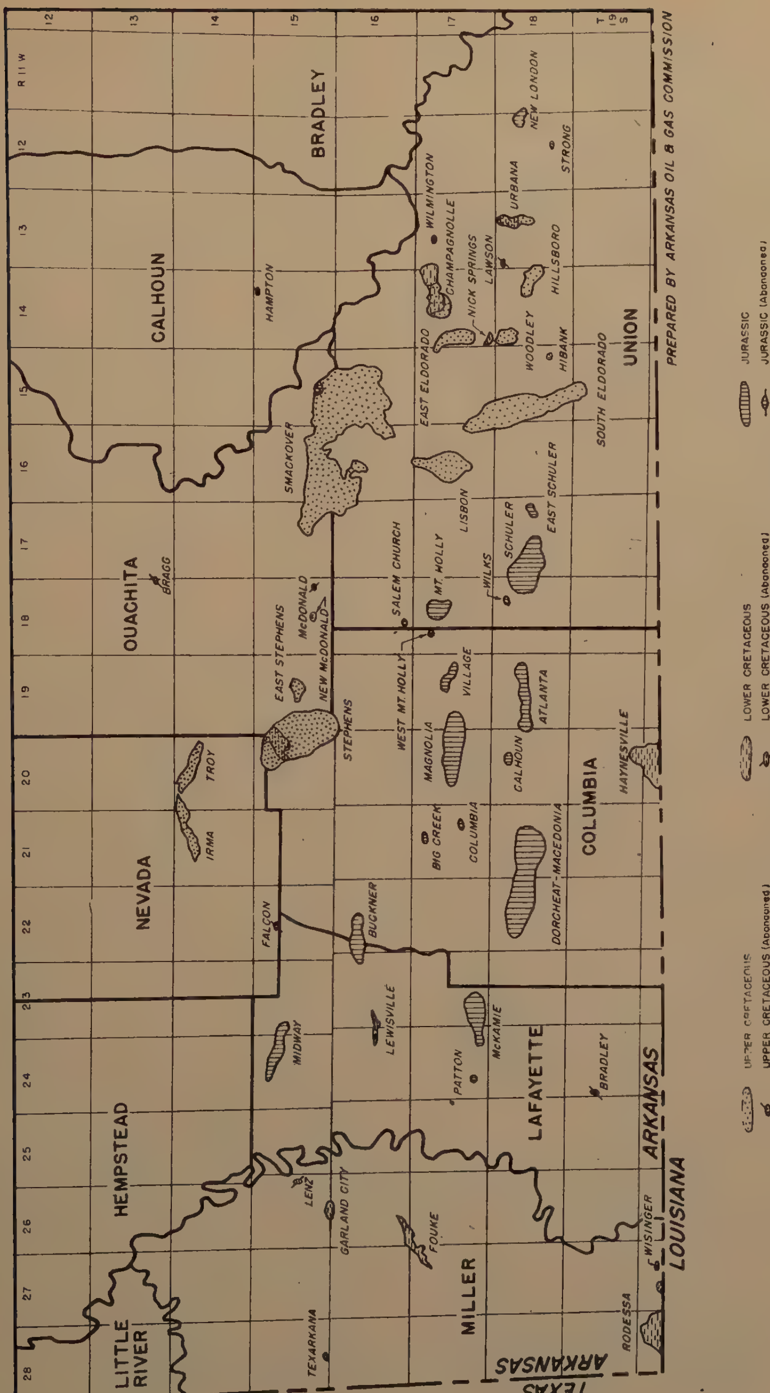

FIG. 6.—OIL AND GAS-CONDENSATE FIELDS, SOUTH ARKANSAS.

rom 5 to 15 ft., largely in the Upper Pettet zone, and drilling was continuing steadily at the end of the year, production not yet having been delimited on the north.

The Ohio Oil Company's completion of its No. 1-P C. G. Taylor Account 4, 2¾ miles south of the Arkansas-Louisiana state line, as Haynesville's first producer from the Cotton Valley, aroused conjecture as to the possibility of extension of production from this series of interbedded sands and shales to the Arkansas side. Because of the depth of this production, stepouts probably will proceed gradually. Unitization of this deeper production similar to that already in force higher in the section is already in process and probably will be effected without difficulty. The deepest well on the Arkansas side is Midstate's No. 1 Beene-Dreyfus in sec. 20, T. 20 S., R. 20 W., which was dry and abandoned at 6002 ft., about 500 ft. below the producing Pettet lime. Ohio's Cotton Valley well is producing at 8835 to 8875 and 8910 to 8920 ft., nearly 3000 ft. lower in the section.

Village.—The Village field of Columbia County, production from which was previously limited to sec. 15 and the west half of the west half of sec. 14, T. 17 S., R. 19 W., was extended south and east through sec. 14, with an indication that one or more locations in sec. 13 might also prove productive. The six wells that proved productive almost doubled the previously established size of the field and, despite the fact that all development took place in the last half of the year, resulted in increasing production for the year almost one third over 1943. In December this development received its first setback with the abandonment as dry of Root's No. B-1 Gunnels, NW ¼ NE¼, sec. 23, T. 17 S., R. 19 W., thus limiting the field on the south.

Atlanta.—During 1944 the West Atlanta field, reported last year as a discovery possibly connecting with the Atlanta field, was sufficiently developed to remove any doubt. It has accordingly been combined with the Atlanta field in this report, and may be noted as an appreciable extension thereof. At the end of 1944, three 40-acre units remained to be drilled to bridge the two areas. The common water level and related pressure-production behavior have definitely established the interconnection, however. Production from the field, largely from the Reynolds lime, increased 22 per cent over 1943. Excessive pressure declines were noted in the last quarter of the year, however, and cutbacks in production were made effective at the first of 1945. Consideration is being given to possibilities of pressure maintenance, but no definite action has been taken pending further observation of reservoir behavior following the decrease in well allowables.

Dorcheat-Macedonia.—At the end of 1944, few proven locations remained to be drilled on the elongated Dorcheat-Macedonia anticlinal structure. The major portion of the year's producers was dually completed in Cotton Valley sands, production from which is obtained appreciably beyond the boundaries established for the Reynolds lime by the oil-water contact in that zone. Of the twenty-eight 80-acre locations drilled, however, 13 fell within the productive limits of the Reynolds lime and were dually completed in that reservoir and in one of the numerous Cotton Valley sandstones. Production from the field increased 45 per cent over the preceding year, and the field ranked fifth in the state in the production of oil and condensate, and first in the production of gas.

Stephens-Smart.—Following establishment by the Petroleum Administration for War late in 1943 of 10-acre spacing regulations for the lenticular sands of the Stephens-Smart field of Columbia, Union, and Ouachita Counties, development was fairly rapid. Whereas the field's producing limits had been reasonably well established in the several productive zones, many inside locations were thus made available. Rigs were kept running throughout the year by the two principal operators in the field, largely within the productive limits established for the Glen Rose and Travis Peak sands. Sand thicknesses encountered in apical wells within these limits, upon the basis of an analysis of electric logs and producing sands, ranged as high as 100 ft. plus or minus. The average for the field, however, is perhaps 27 feet.

Production for the year from the Smart area was nearly 20 per cent greater than in 1943. Production from the shallower Buckrange sand

also registered a slight increase, partly attributable to some 1944 completions and recompletions therein. Wells drilled beyond the productive limits of the deeper sands found in the Smart area have been made producers in this sand, which was first drilled in 1922 and is still producing in many of the original wells.

Acknowledgments

The author is pleased to acknowledge the assistance received from W. C. Dennis, of the Lion Oil Refining Co., and J. C. Thompson, of the Root Petroleum Co., in the preparation of this review and the accompanying detail. Acknowledgment is also gratefully made of assistance given by members of the staff of the Arkansas Oil and Gas Commission.

Northwest Arkansas

In 1943 Alec M. Crowell and Thomas D. Bailey, then respectively Director and Engineer of the Arkansas Oil and Gas Commission, prepared a resumé of activities in Northwest Arkansas from the earliest noted production of natural gas in that area (1887) through the year of 1942 for publication in Petroleum Development and Technology for the latter year (Trans. A. I. M. E., vol. 151). No similar review of developments was prepared for 1943, and it is therefore the purpose of this summary to cover both 1943 and 1944. An annual review of this area is contemplated henceforth.

A base map of the Northwest Arkansas gas area, which has thus far proved unproductive of oil, is presented in Fig. 5. Structural contour maps of this area have not yet been prepared by the Geological Department of the Arkansas Oil and Gas Commission, but present productive outlines are shown for each field. All production is obtained from sands in the Atoka formation of Pennsylvanian age.

Production in 1943 totaled 5,630,000,000 cu. ft. of dry sweet gas, as compared with 5,736,000,000 cu. ft. for the preceding year. In 1944 production again declined to 4,878,000,000 cu. ft., representing a total reduction of 15 per cent from the peak production year of 1942. The appreciable decline in production during 1944 was largely attributable to an increase in take by the Arkansas Oklahoma Gas Co. from the nearby Spiro gas field in Oklahoma. Maximum production of 2,286,000,000 cu. ft. was taken from the Clarksville field of Johnson County, Arkansas. Detailed listing of production is provided in Table 1.

Although virtually all of the favorable shorter anticlinal structures are understood to be under lease, little drilling has been done in the past two years. Wells going below 1000 ft., together with the results of such tests, are listed in Table 2. Only one wildcat, the Arkansas Western Gas Company's No. 1 Harold Woolsey, sec. 13, T. 10 N., R. 27 W., Franklin County, found production, resulting in the discovery of the White Oak field.

New Fields

White Oak.—The White Oak field of Franklin County was discovered May 14, 1943, by the Arkansas Western Gas Co. Discovery well was the No. 1 Harold Woolsey, 660 ft. north of the south line and 730 ft. east of the west line of sec. 13, T. 10 N., R. 27 W. Shut-in pressure of 595 lb. was registered in the producing sand at 1360 to 1380 ft., and initial potential was 33 million cubic feet of gas per day. The well record also took note of gas sands encountered at 964 and 1155 ft. in the process of drilling, for which cable tools were used.

The White Oak anticline has been favorably described by Carey Croneis[2] as a broad, open, essentially symmetrical fold, extending from sec. 26, T. 10 N., R. 28 W., northeastward to sec. 17, T. 10 N., R. 26 W., and having evidence of closure on both ends. It was recommended that a test well be drilled near the crest, preferably in R. 27 W., and that it be carried at least to 4000 feet.

The discovery well was located upon the crest of the surface structure as detailed by

[2] C. Croneis: Geology of the Arkansas Paleozoic Area. Ark. Geol. Survey *Bull.* 3 (1930).

Milton M. Mershon in 1930 and checked prior to drilling by J. D. Thompson of Amarillo, Texas, and was bottomed at 1380 ft. in gray and black shaly gas sand having a porosity approaching 20 per cent. The second well drilled was Arkansas Western's No. 1 Dolen Vernon, in the center of the NE¼ NW¼ NE¼, sec. 23, T. 10 N., R. 27 W. This well was bottomed at 1325 to 1345 ft. in the same sand as the discovery well, and had an initial potential of 35 million cubic feet of gas per day. The third well drilled was the same company's No. 1 Smith-Henson, in the center of the NW¼ NW¼, sec. 24, T. 10 N., R. 27 W. This well encountered the best gas sand between 2645 and 2670 ft., and the test was halted at 2671 ft. Initial shut-in pressure was 954 lb. The fourth producer in the field, Arkansas Western's No. 1 Sells, in the center of the SW¼ SE¼, sec. 13, T. 10 N., R. 27 W., was completed Dec. 16, 1944. It was drilled to 3029 ft. and encountered a good gas sand in the last 12 ft., with reservoir pressure reported as 966 pounds.

Through the end of the year, field production (553 million cubic feet) was obtained from the shallow sand topped at 1325 ft. The other sands were not produced. Reserves for each sand were estimated at 5 billion cubic feet, or 15 billion for the field. On Dec. 31, 1944, one additional location had been staked in the field by Arkansas Western, and Sherrod and Apperson were readying a test 2½ miles southeast of the proven territory in their No. 1 Moyer. Further extension of the field may be expected in the coming year.

Extensions

Silex.—The Silex field, Pope and Johnson Counties, was discovered Oct. 23, 1942, by the Arkansas Louisiana Gas Company's No. 1 Ladd and Strong well, in the center of the SW¼ SW¼, sec. 22, T. 10 N., R. 21 W. Initial production from the Silex anticline, recommended for an exploratory test by Carey Croneis,[2] was 26 million cubic feet of gas per day from sands at 2475 to 2514 ft. and 2802 to 2817 ft. having an average porosity of 26 per cent. A shallower gas sand was also encountered at 937 feet.

In the ensuing two years, four additional wells have been drilled, but only one of these has proved productive. This was Arkansas Louisiana's No. 1 J. B. Hendrix, across the county line from the discovery well, 2371 ft. north and 2229 ft. west of the southwest corner of sec. 21, T. 10 N., R. 21 W., Johnson County, Arkansas. Initial potential was only one million cubic feet of gas per day through perforations in tight sands at 2740 to 2810 and 2869 to 2895 ft. In view of the three failures on near-by locations, attributable to the variable character of the producing sand bodies as encountered in the different wells, no further drilling is contemplated.

Tates Island.—The Tates Island field, Pope County, was extended one location northward by the Sherrod and Apperson No. 1 Brinkman well, in the center of the NE¼ NW¼, sec. 15, T. 9 N., R. 21 W. Initial potential for this well, which encountered the producing sand at 1051 ft., was 6 million cubic feet of gas per day. Completion date was July 23, 1944, and shut-in pressure was 340 lb. Production in the field is understood to be obtained in a graben area, limited to the north and south by faulting and to the east and west by lensing.

Acknowledgments

The writer is pleased to acknowledge assistance received in the preparation of this review from A. B. Harper and S. R. Walker, of the Fort Smith Gas Co.; Leigh Kelly, of the Kelly Trusts; Bill Dalton and Hampton Halsell, of the Arkansas Western Gas Co.; and Robert L. Breedlove and William L. Stanton, of the Arkansas Louisiana Gas Co. Acknowledgment is also gratefully accorded members of the staff of the Arkansas Oil and Gas Commission.

Oil and Gas Development in California in 1944

By L. E. Porter,* Member A.I.M.E., and H. P. Hassel*

General

The state of California produced 310,996,696 bbl. of oil and about 415,832,000 M cu. ft. of gas in 1944. Such oil production represented 18.5 per cent of the nation's production, as compared with 19 per cent in 1943. The tremendous demand placed upon the California fields is indicated by the monthly production in 1944, as follows:

Month	Barrels per Day
Jan.	809,262
Feb.	820,712
Mar.	824,592
Apr.	829,973
May	832,068
June	846,038
July	849,231
Aug.	858,932
Sept.	885,823
Oct.	877,667
Nov.	876,613
Dec.	883,847

In all, 2100 wells in proved areas and 269 wildcats were drilled in California during the year 1944. At the end of the year, approximately 270 wells were drilling in the state, as compared with 156 wells at the same time in the preceding year. Nine new fields or new zone discoveries were made during the year, which, according to best estimates, will contribute some 77,000,000 bbl. of new reserves; in addition, the extensions of old fields will increase the new reserves about 165,000,000 bbl., or a combined total, through discoveries of new fields, zones, and extensions, of 242,000,000 bbl., offsetting to the extent of about 78 per cent the total oil produced during the year. Geographically, the reserves from these new field and zone discoveries and extensions are distributed as follows:

	Per Cent
San Joaquin Valley	72
Coast Area	24
Los Angeles Basin Fields	4
	100

The state's reserves of crude oil at the end of the year have been estimated to be distributed as follows:

Area	Thousand Bbl.	Per Cent
San Joaquin Valley	1,900,000	55.5
Coast Area	550,000	16
L. A. Basin	980,000	28.5
Total, state	3,430,000	100

The outstanding development project for the year was that of the United States Navy in the Naval Petroleum Reserve No. 1, Elk Hills field. During the year, 115 wells were completed in this field, and at the close of the year an average of 19 strings of tools were drilling. This program is being jointly conducted by the Standard Oil Co. of California with the Navy and is designed to increase the production of Naval Petroleum Reserves from approxi-

Manuscript received at the office of the Institute April 16, 1945.

* Richfield Oil Corporation, Los Angeles, California.

mately 15,000 bbl. a day as at the beginning of 1944 to at least 65,000 bbl. a day at the conclusion of the program, which probably will be some time in the spring of 1945. Production during December 1944 was averaging about 42,100 bbl. per day. The program is reported to be well ahead of schedule.

The next outstanding development occurred in the Buena Vista Hills in the Buena Vista "27" pool, which was discovered by the Standard Oil Co. of California on the United Anticline in its well No. 54-27-B; subsequent development has proved between 3500 and 4000 acres.

The world's deepest test, the Standard Oil Company's KCL 20-13 in sec. 5, T. 31 S., R. 25 E., South Coles Levee area of Kern County, reached the all-time world's record depth of 16,246 ft. when drilling was suspended in December. Unfortunately, no commercial production was obtained in the well and it is scheduled to be abandoned. Nevertheless, this record well is an incentive mechanically for deeper drilling throughout the state; for example: deep projects have been started at Long Beach and Dominguez fields in Los Angeles County; others are either contemplated or being drilled in such important fields as Lost Hills, Semitropic, and Gonyer anticline areas of Kern County.

Pressure Maintenance, Gas Cycling, and Gas Injection

One of the outstanding contributions of added oil reserves is occurring through the methods of pressure maintenance, gas cycling and injecting projects. There was injected during December 1944, 7,618,000 M cu. ft. of gas in the following fields:

North Belridge
North Coles Levee
Kettleman North Dome
Paloma
Canal
Orcutt
San Miguelito
Newhall-Potrero
Lompoc
West Coyote

In Kern County, the construction of a 55,000 M cu. ft. gas-cycling project is under way at South Coles levee, while in the Paloma field gas cycling is being conducted with a field production of 785 bbl. per day. The pressure-maintenance project started some two years ago at North Coles levee is continuing favorably.

Throughout the state, in old fields, several interesting experiments are being conducted on secondary recovery operations, some of which may show promise during the year 1945 as to the potential possibilities thereof.

Natural Gas Development

Forty-eight natural gas wells were completed during the year. Important gas reserves have been uncovered in nine fields or areas by the following wells:

San Joaquin Valley Fields:

Richfield Oil Corporation Chico No. 1, sec. 17, 21 N. 1 E., Butte County.

Richfield Oil Corporation Afton Community No. 1, sec. 34, 19 N. 1 W., Glenn County.

Superior Oil Company Knight No. 1, sec. 13, 21 N. 2 W., Glenn County.

Amerada Petroleum Corporation Starkey Fee No. 1, Sec. 2, 6 N. 2 E., Solano County.

Shell Oil Company Lambie No. 1, sec. 25, 4 N. 1 W., Solano County.

Standard Oil Company Perry Anderson H-6, sec. 36, 4 N. 2 E., Rio Vista Gas field, Solano County.

Standard Oil Company Honker Community No. 1-A, sec. 25, 3 N. 1 W., Suisun Bay area, Solano County.

Standard Oil Company Cutter Unit No. 1, sec. 29, 23 S. 22 E., Trico Alpaugh area, King County.

Coast Area:

Pacific Lighting Corporation Miller No. 1, sec. 20, 4 N. 28 W., Santa Barbara County.

New Discoveries—Oil Fields and Important Extensions

San Joaquin Valley District

The Antelope Plains area came into production in June with the completion of the Shell Oil Company Hopkins Fee 57 X. 31 in sec. 31, T. 27 S., R. 20 E., for approximately 47 bbl. per day of 16.4° gravity oil from a depth of 2520 feet.

The Amerada Petroleum Corporation discovered a new field in the Ant Hill area southwest of the old Kern River field, Kern County, when it completed its S.P. 36-15 in sec. 15, 29 S. 29 E., for approximately 175 bbl. of 14° gravity oil in the Olcese sand (Miocene) from a depth of 2225 feet.

In the Belleview area of Kern County, the Superior Oil Co. opened up a new field from the McClure formation (Miocene) when it completed its Houghton 36-35 for almost 1900 bbl. per day of 36° gravity oil, 2850 M cu. ft. of gas; 550 lb. flow pressure; total depth 8761 ft., plugged 6694 ft. The well also showed possible production from the Vedder zone of Miocene age.

Buena Vista "27" Pool, Buena Vista Hills United Anticline, Kern County

The discovery by the Standard Oil Co. of production from the "27" pool in its well No. 54-27 B., drilled in sec. 27, 31 S. 23 E., opened up the most important oil reserve uncovered in the state during the year 1944. The discovery was made between the depths of 4273 and 4303 ft. By the end of the year, some 46 wells had been drilled and completed in this pool, proving up 3500 to 4000 acres. The E-2 sand averages between 40 and 45 ft. in thickness. In better portions of the field, the lower or E-3 sand is also taken in and, where productive, averages between 25 and 30 ft. in thickness. Both sands are of lower Pliocene age.

In the Gosford district, Kern County, the Associated Oil Co., in its well KCL 44-22 in sec. 22, T. 30 S., R. 26 E., made a pumping well of 143 bbl. per day, 31° gravity oil, in 15 ft. of zone at 7935 ft. (T.D. 8152 ft.); Stevens sands (Miocene).

In the Jacalitos area, Fresno County, the Standard Oil Co., in its well No. 67-17-E in sec 17, T. 21 S., R. 15 E., obtained a blow of 3500 M cu. ft. of gas from sand of lower Miocene. Subsequent wells have produced 32° to 34° gravity oil.

The Dwight Vedder interests made a discovery in the West Mount Poso district of Kern County by completing their second test well, No. 3-18 in sec. 18-27-28, for about 100 to 150 bbl. per day of 16.3° gravity oil. Also in Kern County, in the Race Track Hill area, the British American Petroleum Co. made a discovery in its Portals Corporation well No. 53-3, which was completed on a production test in Sept. 1944, when it produced 250 bbl. of 37° gravity oil in a test of the formation between 4720 and 4768 ft. The well was then cased and completed for 240 bbl. per day of 37° gravity oil; estimated 120 to 125 M cu. ft. of gas. The oil zone is reported between 4727 and 4755 feet.

The Rothschild-Bender interests made a discovery on their property in the Sheep Springs area in sec. 17, T. 29 S., R. 21 E., upon the completion of well No. 2 as a flowing well for 434 bbl. per day of 23.9° gravity oil, showing very little gas. The wells supposedly are producing from the Carneros formation of Miocene age.

Coast Area

In the Coast area, no important discoveries were made during the year,

TABLE 1.—*Oil and Gas Production in California*

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Producible Wells End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944, Oil: Flowing	Wells Producing[g] Dec. 1944, Oil: Artificial Lift
	SAN JOAQUIN VALLEY												
1	Antelope Plains, *Kern*	1944	225	5,606	5,606				1	1			1
2	Ant Hill, *Kern*	1944	125	17,018	17,018				3	3			3
3	Belleview, *Kern*	1944	125	158,036	158,036				3	3		3	
4	Belridge, North, *Kern*	1912	2,500	50,145,820	2,343,388		342,054	8,252	117	4		44	22
5	Belridge, South, *Kern*	1911	6,000	30,393,630	3,981,712				692	208		2	662
6	Buena Vista, *Kern*	1909	22,000	297,840,326	5,118,664		Included in Midway-Sunset		838	23	4		818
7	Buena Vista, sec. 27 pool, *Kern*	1944	3,500	1,769,733	1,769,733				46	46		44	1
8	Burrel, *Fresno*	1943	75	12,141	6,213				2	1		1	1
9	Canal, *Kern*	1937	990	10,399,848	1,296,490		9,771	799	39			23	12
10	Coalinga, East, *Fresno*	1900	7,600	241,710,317	8,001,320				696	95	12		670
11	Coalinga, West, *Fresno*	1900	11,400	153,277,991	2,656,849				788	67	4		735
12	Coalinga, Nose, *Fresno*	1938	3,500	60,952,928	20,771,526		57,687	18,686	173	4		142	13
13	Coalinga, Northeast, *Fresno*	1939	1,300	16,003,584	3,929,867				56		4	44	3
14	Coffee Canyon, *Kern*	1928	450	11,483,020	565,957				62		1		61
15	Coles Levee, North, *Kern*	1938	2,450	19,561,331	5,769,791		35,051	250	88	4	1	69	2
16	Coles Levee, South, *Kern*	1938	3,400	7,288,303	924,717				54	3		27	
17	Edison, *Kern*	1934	2,060	11,254,701	1,035,720		Incl. in Mountain View		146	26	3		139
18	Elk Hills, *Kern*	1919	13,000	175,195,688	7,722,107		84,012	1,585	348	115		3	337
19	Fruitvale, *Kern*	1928	2,250	32,190,729	3,027,677				203	23		3	190
20	Gosford, *Kern*	1944	225	11,676	11,676				2	2		1	1
21	Greeley, *Kern*	1936	1,800	19,028,561	5,215,847		27,768	4,684	91	7		76	14
22	Helm, *Fresno*	1941	3,860	750,030	499,822		3,665	1,482	30	17		25	1
23	Jacalitos, *Fresno*	1941	1,075	405,525	227,150				16	9		7	9
24	Kern Front, *Kern*	1925	4,250	55,828,714	3,194,563				571	51	1		557
25	Kern River, *Kern*	1899	6,100	286,927,354	3,478,123				2,228	34			2,139
26	Kettleman, North, *Kern & Fresno*	1928	16,720	295,640,550	15,134,783		1,743,220	83,652	353	14	1	113	165
27	Lanare, *Fresno*	1943	200	67,989	53,120		Incl. in Helm		6	3		2	4
28	Lost Hills, *Kern*	1910	2,560	55,287,711	1,272,352			780	375	1	1		369
29	McClung, *Kern*	1943	25	66,253	47,524				2				2
30	McKittrick District, *Kern*	1887	1,525	97,658,047	1,793,389				339	34	2		327
31	Midway-Maricopa, *Kern*	1901	33,000	675,441,258	15,119,810		409,103	11,813	2,807	140	9		2,716
32	Mountain View, *Kern*	1933	1,850	44,689,316	1,154,277		51,713	709	162	7	2		149
33	Mt. Poso District, *Kern*	1926	3,100	78,131,476	7,959,947				483	26	2		466
34	Paloma, *Kern*	1939	4,000	2,007,679	1,228,972		5,355	2,732	25	14		15	
35	Pleasant Valley, *Fresno*	1943	550	1,177,389	942,576		878	691	16	11		16	
36	Poso Creek District, *Kern*	1929	1,625	7,675,157	1,694,997				193	33	2		182
37	Race Track Hill, *Kern*	1944	80	6,944	6,944				2	2		2	
38	Raisin City, *Fresno*	1941	700	1,676,143	926,810		4,275	1,309	30	15		24	5
39	Rio Bravo, *Kern*	1937	2,140	27,681,909	5,920,530		30,883	7,218	101	1		93	4
40	Riverdale, *Fresno*	1941	2,000	2,222,289	1,523,264		3,176	2,081	53	20		48	
41	Round Mountain, *Kern*	1927	1,800	31,165,304	3,334,359				238	17	1		234
42	Sheep Springs, *Kern*	1944	40	35,250	35,250				2	2		2	
43	Strand, *Kern*	1939	380	3,127,239	815,123		2,229	657	22	5		16	6
44	Ten Section, *Kern*	1936	2,260	31,578,442[1]	4,623,765		65,485	17,382	123			113	5
45	Tejon, *Kern*	1943	280	65,016	61,464				6	6			6
46	Union Avenue, *Kern*	1941	75	194,229	37,270				5				3

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Revised from supplemental data.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Secondary Recovery[h]	Gravity A.P.I. 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
					SAN JOAQUIN VALLEY							
1	50		17		Mio, Eoc	S	x	2,485	35	AC(?)	Eocene	2,917
2			39–40; 13–18		Olcese, Mio	S	x	2,180	45	MF	Basement	4,159
3			35		McClure, Mio	S	x	6,570	40	MCF	Stevens-Miocene	8,761
4	2,300; 3,750	G	34.5	0.25	Etch.-Temb.-Vaq., Pli, Mio	S	14	4,917	625	A	Cretaceous	10,800
5			24	0.83	Etch.-Temb., Pli, Mio	S	x	800	50	A	Miocene	11,377
6		G	26.6	0.59	San Joaquin Clay-Etch., Pli	S	25	2,665	50	A		
7			27–32		E-2 & E-3, Pli	S	25			AC	Miocene	14,622
8			27		Mio	S	20	6,484	15	AC(?)	Miocene	6,660
9	3,550		37.5	0.70	Stevens, Mio	S	22	8,250	160	A	Miocene	13,400
10			21.0	0.67	Etch.-Temb., Pli, Mio	S	25	1,860	170	AUP	Cretaceous	9,418
11			15.8	0.45	Etch.-Sta. Marg., Pli, Mio	S	x	900	180	MUP	Cretaceous	4,883
12	3,450		33	0.40	Avenal, Eoc	S	19	6,400	360	MU	Eocene	8,416
13	3,740		28	0.24	Avenal, Eoc	S	23	7,980	130	MU	Cretaceous	9,614
14			16	0.60	Vedder, Mio	S	x	1,600	60	MU	Incl. with Round Mountain	
15	3,700	P	36	0.40	Stevens, Mio	S	20	8,000	320	AM	Miocene	10,120
16	4,300	P	44		Stevens, Mio	S	20	8,300	200	AM	Miocene	16,246
17			18.5	0.75	Kern River-Vedder, Pli, Mio	S	x	1,500	125	MU	Jurassic	6,026
18			22.1	0.57	San Joaquin Clay-Etch.-Stevens, Pli, Mio	S	38	2,600	75	A	Miocene	11,177
19			19.8	0.60	Etch.-Chanac, Pli	S	x	3,000	88	MU	Schist-Jurassic	10,590
20			29–35		Stevens, Mio	S	x	7,920	15	x	Miocene	8,152
21	3,200; 4,890		38.5	0.28	Stevens-Vedder, Mio	S	21	11,430	290	AM	Eocene	13,538
22			65	0.02	Temblor-Eocene, Mio, Eoc	S	30	7,300	50	AM	Cretaceous	10,257
23			40	0.48	Temblor, Mio, Eoc	S	x	3,865	11	AF	Cretaceous	6,031
24			14.4	1.29	Etchegoin, Pli	S	35	1,700	80	MF	Jurassic slate	6,211
25			13.3	1.07	Kern River, Pli	S	35	400	130	MU	Miocene	5,135
26	3,200; 4,500	P	36.5	0.30	Temblor-Avenal, Mio, Eoc	S	15	6,300; 10,200	850	A	Cretaceous	12,884
27			32–35; 40		Eoc	S	21	8,018	42		Eocene	8,203
28			18	0.99	Etchegoin, Pli	S	x	1,170	80	A	Miocene	7,858
29			29		Stevens, Mio	S	22	7,482	15	AC	Eocene	13,131
30			14.2	1.02	Etchegoin, Pli	S	x	800	350	MUF	Oligocene	9,510
31			17.5	0.75	Etch.-Maricopa-Chanac, Pli, Mio	S	30	1,950	65	MUF	Miocene	10,410
32			26	0.66	Chanac-Sta. Marg., Pli, Mio	S	x	6,080	55	MF	Granite	8,624
33			15.4	0.71	Vedder, Mio	S	35	1,600	150	MF	Granite	3,130
34	4,750	P	51	0.20	Stevens, Mio	S	20	10,140	200	A	Miocene	11,216
35			29.5		Avenal, Eoc	S	14	8,940	200	AC	Eocene	9,255
36			13:7		Vedder, Mio	S	x	2,000	35	MU	Vedder-Miocene	5,492
37			39–41		Mio	S	x	4,727	30	MF	Franciscan	5,551
38			30	0.16	Temblor-Eocene, Mio, Eoc	S	21	5,040	10	A	Eocene	9,562
39	4,750		38.5	0.32	Vedder, Mio	S	22	11,249	220	A	Schist-Jurassic	14,108
40			35		Miocene-Eocene	S	x	6,500	35	AU	Slate-Jurassic	11,990
41			16.5	0.60	Jewett-Vedder, Mio	S	34	1,950	66	MF	Vedder-Miocene	3,760
42			24		Carneros(?), Mio	S	x	3,456	21	AM	Miocene	3,730
43	3,600		35	0.37	Stevens, Mio	S	23	8,320	115	D	Miocene	12,818
44	3,550	P	35.4	0.34	Stevens, Mio	S	20	7,850	200	A	Miocene	10,023
45			18.3		Chanac, Pli	S	x	2,620	40	MU	Miocene	5,444
46			14.0		Chanac, Pli	S	x	4,200; 5,050	30	MF	Oligocene	10,427

TABLE I.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944	
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Producible Wells End of 1944	1944		Oil	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned	Flowing	Artificial Lift
47	Wasco, *Kern*	1938	360	3,771,776	822,791			337	13			6	7
48	Wheeler Ridge, *Kern*	1922	300	4,204,898	91,456				34				34
49	Williams, *Kern*	1942	250	1,527,023[1]	673,759		1,061	583	28	8		1	25
50	Others			1,205,149	166,437			1,949	50	39	2		35
51	San Joaquin Valley total			2,848,917,046	147,170,541			167,631	12,761	1,144	52	965	11,135
	COASTAL DISTRICT												
	Santa Barbara District												
52	Capitan, *Santa Barbara*	1929	296	8,749,124	1,080,024		4,841	501	53				50
53	Elwood, *Santa Barbara*	1928	480	73,110,633[1]	2,129,347		67,623	1,138	66	3	2	1	61
54	Santa Barbara, *Santa Barbara*	1929	140	3,486,404	33,068				16		2		15
	Santa Maria District												
55	Casmalia, *Santa Barbara*	1904	1,150	14,990,483	179,506				19	2			17
56	Cat Canyon, *Santa Barbara*	1908	1,700	24,643,612[1]	2,531,706				65	13	1	12	46
57	Gato Ridge, *Santa Barbara*	1931	475	9,865,212	1,770,227				31	5			29
58	Lompoc, *Santa Barbara*	1903	2,735	11,852,578	644,027				31				30
59	Orcutt, *Santa Barbara*	1903	4,500	101,557,362	1,459,334			12,078	207	1			199
60	Santa Maria Valley, *Santa Barbara*	1934	6,100	49,246,184	11,306,301				351	88		42	298
	Ventura District												
61	Padre Canyon, *Ventura*	1936	180	2,935,069	491,608		22,913	622	25	5		8	16
62	Rincon, *Ventura*	1927	625	17,804,604	1,502,087			1,782	93	15		15	70
63	San Miguelito, *Ventura*	1931	300	10,769,351	2,090,517		17,569	5,218	34	5		29	2
64	Ventura Avenue, *Ventura*	1916	2,200	285,511,775[1]	17,487,482		930,092	46,540	520	36		213	272
	Santa Paula-Newhall District												
65	Bardsdale, *Ventura*	1894	200	3,606,905	75,440		Incl. in Shiells Canyon		29	2			29
66	Del Valle, *Los Angeles*	1940	700	3,639,596	1,474,305		9,568	3,657	36	11		27	9
67	Ex-Mission, *Ventura*	1875	130	22,164,019[2]	9,890				25				22
68	Holser Canyon, *Ventura*	1942	30	26,208	6,338				1		1		1
69	Hopper Canyon, *Ventura*	1887	153	6,461,459[3]	32,730				9				4
70	Newhall, *Los Angeles*	1875	110	5,901,601[4]	21,689				21				8
71	Newhall Potrero, *Los Angeles*	1937	750	7,473,531	1,893,785		7,535	3,585	46	4		36	1
72	Oak Canyon, *Los Angeles*	1941	200	906,581	416,458			391	12	2		7	5
73	Oxnard, *Ventura*	1937	100	1,080,806	431,466				5	3			5
74	Sespe Canyon, *Ventura*	1887	289	3,191,616[5]	82,348				26	1	4		20
75	Shiells Canyon, *Ventura*	1911	950	11,742,440	566,574	Incl. in South Mountain		1,000	144	19			135
76	Simi-Conejo, *Ventura*	1912	635	2,409,241	27,569				54				54
77	Sisar-Silverthread, *Ventura*	1885	330		44,222				71				68
78	South Mountain, *Ventura*	1916	890	24,302,795	560,718		74,683	2,116	100	4			100
79	Temescal, *Ventura*	1924	120	2,836,345	329,348			429	22	2			21
80	Timber Canyon, *Ventura*	1885	110		9,083				8				8
81	Torrey Canyon, *Ventura*	1896	140		52,395				38				38

[2] Accumulative includes Timber Canyon, Sisar-Silverthread, Sulphur Mountain, Tip-Top-Fresno Canyon.
[3] Accumulative includes Modelo, Tapo-Eureka, Torrey Canyon, Hopper Canyon.
[4] Accumulative includes Elsmere Canyon, Pico Canyon, Wiley-Towsley Canyon.
[5] Accumulative includes Topa-Topa.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
47	5,670		38	0.26	Vedder, Mio	S	15	13,100	25	A	Eocene	15,004
48			23.5		Etch.-Sta. Marg., Pli, Mio	S		2,000	40	A	Eocene	11,681
49			16.6	0.77	Miocene, Mio	S	30	2,200	60	AU	Oligocene	3,584
50												
51												
					COASTAL DISTRICT							
52			28	0.45	Vaqueros-Sespe, Mio, Olig	S	*x*	1,150	135	AF	Eocene	4,501
53			33.7	0.30	Monterey-Vaq.-Sespe, Mio, Olig	S	25	2,800	330	AF	Eocene	7,151
54			17	0.60	Vaqueros, Mio	S	*x*	1,960	75	MF	Sespe	4,730
55			10.3	2.84	Sisquoc-Monterey, Mio	H	*x*	1,200	Fis	A	San Lorenzo Olig	5,300
56			13.5	4.13	Sisquoc, Mio	S & H	*x*	2,000	Fis	A	Cretaceous	7,199
57			13.9	5.42	Sisquoc-Monterey, Mio	H	*x*	1,800	Fis	AF	Vaqueros, Miocene	6,510
58			20.5	3.4	Sisquoc-Monterey, Mio	S & H	*x*	2,200	Fis	A	Eocene (?)	4,990
59			22.6	2.63	Sisquoc-Monterey, Mio	S & H	*x*	1,100	Fis	A	Sespe-Oligocene	5,915
60	1,750	G	15.9	4.64	Monterey, Mio	S & H	*x*	4,000	Fis	MU	Franciscan	8,133
61	2,400		29.1	0.80	Pico-Repetto, Pli	S	*x*	4,800	140	AF	Miocene	6,751
62			30	0.80	Pico-Repetto, Pli	S	*x*	2,500	140	A	Pliocene	10,515
63	2,720	G	30		Pico-Repetto, Pli	S	*x*	5,500	680	AF	Pliocene	10,030
64	2,750		30	0.73	Pico-Repetto, Pli	S	*x*	3,400	3,000	A	Pliocene	11,740
65			32.1	0.83	Sespe-Tejon, Olig-Eoc	S	*x*	500	*x*	A	Eocene	6,804
66	2,800		32	1.21	Modelo, Mio	S	28	6,037	107	A	Miocene	9,850
67			25.2	0.70	Repetto, Pli	S	*x*	500	*x*	MF	*x*	*x*
68			16.5		Modelo, Mio	S	*x*	5,200	*x*	A	Miocene	8,147
69			29		Modelo, Mio	S	*x*	1,500	*x*	A	Miocene	5,002
70			20.0		Modelo, Mio	S	*x*	858	*x*	A	Cretaceous	4,400
71	3,200		33.3	0.54	Modelo, Mio	S	16	6,160	230	AF	Miocene	8,120
72			33	0.83	Modelo, Mio	S	22	2,365	80	A	Miocene	8,090
73			8		Modelo, Mio	S	*x*	2,100	200	MU	Miocene	4,285
74			26.0	0.50	Sespe, Olig	S	*x*	400	*x*	A & S	Olig.-Eocene	3,595
75			33.0	0.69	Sespe, Olig	S	*x*	2,100	640	A	Eocene	7,428
76			28.1	0.68	Meganos, Eoc	S	*x*	1,100	*x*	A	Eocene	3,934
77			18.5		Sespe, Olig	S	*x*	315	*x*	MF	Eocene	8,755
78			23.9	1.73	Sespe, Olig	S	*x*	2,200	956	A	Eocene	6,702
79			22		Modelo, Mio	S	*x*	2,000	*x*	A	Miocene	10,313
80			28.7		Repetto-Modelo, Pli-Mio	S	*x*	300	*x*	MF	Eocene (?)	6,884
81			27.5		Vaqueros-Sespe, Mio-Olig	S	*x*	700	*x*	AF	Olig	6,146

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Producible Wells End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944, Oil: Flowing	Wells Producing[g] Dec. 1944, Oil: Artificial Lift
	Other Coastal Counties												
82	East Elberta pool, *San Luis Obispo*........	1943	20	25,821	22,744				1				1
83	Pismo, *San Luis Obispo*	1928	200	113,358	6,464				2				2
84	Sargent, *Santa Clara*...	1886	60	339,475	8,134				9				9
85	Others................			4,135,514	54,372			699	50	3	2		44
86	Coastal District total..			714,888,702	48,831,306			79,756	2,220	224	12	390	1,689
	LOS ANGELES BASIN DISTRICT												
87	Alamitos, *Los Angeles*..	1931	150	24,999,419	257,089		Incl. in Seal Beach		36				35
88	Aliso, *Los Angeles*.....	1938	950	4,278,926	1,099,860			835	32	7		11	16
89	Brea Olinda, *Orange*...	1889	1,900	180,116,760	4,270,336		67,706	3,333	380	5		1	357
90	Buena Park, *Orange*...	1942	75	123,549	36,650				2	1			2
91	Coyote, East, *Orange*..	1911	1,300	49,659,879	1,972,053		67,939	6,469	157	13			156
92	Coyote, West, *Orange*..	1909	1,180	138,083,996	4,433,323				179	20		29	145
93	Dominguez, *Los Angeles*	1923	1,200	155,170,828	7,872,378		255,921	12,968	314	9	1	13	295
94	El Segundo, *Los Angeles*	1935	550	11,252,951	329,657		7,923	136	36	2	2		34
95	Huntington Beach, *Orange*.............	1920	2,600	343,349,089	17,140,810		344,431	13,357	845	70	9	50	759
96	Inglewood, *Los Angeles*	1924	975	145,805,304	6,460,262		114,031	7,516	309	6	1	19	285
97	Kraemer, *Orange*......	1920	200	1,622,508	33,137		Incl. in Richfield		10				10
98	Long Beach, *Los Angeles*	1921	1,400	698,985,925	10,791,858		901,051	9,239	1,196	6	10		1,152
99	Los Angeles dist., *Los Angeles*.............	1892	1,625	66,583,841	183,019				91		1		91
100	Montebello, *Los Angeles*	1917	2,100	139,042,518	3,904,495		115,470	4,590	364	11	4	1	346
101	Playa Del Rey, *Los Angeles*.............	1934	670	50,592,105	946,933		51,476	454	125				122
102	Potrero, *Los Angeles*...	1928	200	5,329,360	399,660			703	26	1		6	19
103	Richfield, *Orange*......	1919	1,370	99,742,711	2,411,212		91,806	2,228	310	7			304
104	Rosecrans-Athens, *Los Angeles*............	1924	850	55,308,608	2,233,743		137,115	4,247	194	3	1	12	165
105	Santa Fe Springs, *Los Angeles*............	1919	1,750	499,064,929	6,830,865		692,356	6,181	574		2		556
106	Seal Beach, *Los Angeles*	1926	400	73,542,267	2,566,360		108,702	2,314	106	6		7	99
107	Torrance-Hermosa, *Los Angeles*............	1922	5,900	113,228,984	3,179,554		82,389	1,735	723	40	11		684
108	Turnbull Canyon, *Los Angeles*...........	1941	80	331,598	86,560		Incl. in Whittier		7	2	1		7
109	Whittier, *Los Angeles*..	1898	675	19,555,825	383,261			426	167	1			160
110	Wilmington, *Los Angeles*...........	1935	5,100	244,593,861	36,765,173		210,272	38,387	1,335	139		281	1,015
111	Yorba Linda, *Orange*...	1919	300	1,661,881	374,359		Incl. in Richfield		32	3	1		27
112	Others................			1,980,739	32,242			148	39	1			26
113	Los Angeles Basin total..............			3,124,008,361	114,994,849			115,266	7,589	353	44	430	6,867
114	STATE TOTAL.....			6,687,814,109	310,996,696			362,653	22,570	1,721	108	1,785	19,691

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In. Initial	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
82			18		Monterey, Mio	S, H	x	800	400	x	Miocene	2,125
83			22		Monterey, Mio	H	x	2,000	900	S	Jurassic schist	4,425
84			13	0.86	Monterey, Mio	S, H	x	900	600	AF	Franciscan	3,583
85												
86												
					Los Angeles Basin District							
87			26.8	1.07	Pico-Repetto-Puente, Pli, Mio	S	x	4,635	250	AF	Miocene	9,054
88	1,750		24	0.47	Pico-Repetto-Modelo, Pli, Mio	S	x	4,795	170	M	Eocene	9,339
89			22.5	0.97	Repetto-Puente, Pli, Mio	S	x	260	800	AF	U.P. Mohnian Miocene	8,201
90			20.9	2.42	Repetto, Pli	S	x	8,900	55	AM	Miocene	11,422
91			25	1.46	Repetto-Puente, Pli, Mio	S	x	2,450	153	AF	Miocene	9,084
92			28.9	0.90	Repetto, Pli	S	22	2,800	473	D	Miocene	9,200
93	{1,700 3,000}		30.4	0.85	Repetto-Puente, Pli, Mio	S	28	3,800	1,460	AF	Miocene	12,720
94			21.8	2.98	Puente, Franciscan, Mio, Jur	S Fis	x	6,890	50	AF	Franciscan Schist	8,009
95	{1,000 1,600}		23.5	1.30	Repetto-Puente, Pli, Mio	S	28	1,900	1,200	MF	Miocene	9,045
96			22.0 32.0	2.51 0.93	Pico-Repetto-Puente-Monterey, Pli, Mio	S	x	1,073	975	AF	Franciscan	12,276
97			23.0	x	Repetto-Puente, Pli-Mio	S	x	4,100	x	A	Incl. in Richfield	
98			25	1.25	Pico-Repetto-Puente, Pli, Mio	S	30	2,377	1,650	AF	Miocene	10,720
99			13.7	1.0	Repetto-Puente, Pli, Mio	S	x	475	9	AF	Miocene	5,074
100			{25 30}	0.80 0.40	} Repetto-Puente, Pli, Mio	S	x	1,730	800	A	Miocene	10,722
101			21	2.7	Repetto-Puente-Franciscan, Pli, Mio, Jur	Fis	x	3,350	200	A	Franciscan Schist	7,048
102			44.5	1.3	Pico-Repetto-Puente, Pli, Mio	S	29	3,640	350	AF	Franciscan Schist	9,923
103		G	20.5	1.60	Puente, Pli	S	x	2,900	510	A	Oligocene-Sespe	10,496
104			33	0.48	Repetto-Puente, Pli, Mio	S	22	4,035	1,050	AF	Miocene	10,389
105			32.5	0.40	Repetto-Puente, Pli, Mio	S	29	3,470	1,360	D	Miocene	11,314
106			25	0.70	Repetto-Puente, Pli, Mio	S	x	4,314	350	AF	Miocene	9,054
107			22.0	1.62	Puente, Mio	S	27	2,637	120	AF	Franciscan Schist	6,957
108			27	0.56	Puente, Mio	S	27	3,300	191	AF	Mohnian Miocene	5,608
109			19	0.77	Repetto-Puente, Pli, Mio	S	x	200	270	MUF	Miocene	8,033
110			{18 25 30}	1.9 1.2	} Repetto-Puente, Pli, Mio	S	32	2,320	420	AF	Franciscan Schist	6,814
111			22		Repetto-Puente, Pli, Mio	S	x	3,400	x		Miocene	5,771
112												
113												
114												

although important extensions have occurred in the Del Valle field where the Standard Oil Co. found a fault accumulation in the San Martinez formation. In the Cat Canyon area of Santa Barbara County, the Pacific Western is developing heavy oil production on its Los Alamos property from depths of about 5800 feet.

At Rincon field, Ventura County, plans are under way for the development of certain offshore state lands, which probably will prove important in the coming year.

Los Angeles Basin Fields

The Shell Oil Co. has started very deep tests in the Long Beach and Dominguez fields, which, before many months, should prove whether productive deep sands are to be encountered in these prolific producing areas.

Conclusion

It is estimated that perhaps as many as 2500 wells will be drilled in the year 1945, as compared with 2369 drilled and com-

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres	B.t.u. of Gas	Total Gas Production, Millions Cu. Ft.		Number of Gas Wells			
					To End of 1944	During 1944	Completed to End of 1944	During 1944		End of 1944
								Completed	Abandoned	Productive Gas Wells
	GAS FIELDS									
1	Afton, *Glenn*	1944	500	840	0	0	1	1	0	1
2	Alpaugh, *Tulare*	1944	500	x	1	1	1	1	0	1
3	Bowerbank, *Kern*	1942	500	995	1,708	869	3	0	0	3
4	Buena Vista Hills, *Kern*	1909	2,000	980	116,852	933	41	0	0	23
5	Buttonwillow, *Kern*	1926	1,700	985	29,025	3,372	30	0	0	12
6	Chico, *Butte*	1944	600	860	0	0	1	0	0	1
7	Coles Levee, *Kern*	1941	700	1,020	10,720	4,338	5	0	0	5
8	Corning, *Tehama*	1944	500	x	0	0	1	0	0	1
9	Dixon (Millar), *Solano*	1944	640	985	28	28	1	0	0	1
10	Elk Hills, *Kern*	1919	5,000	980	76,785	1	10	0	0	5
11	El Segundo, *Los Angeles*	1942	160	993	3,653	1,344	4	0	0	3
12	Fairfield Knolls, *Yolo*	1937	960	945	480	77	2	0	0	2
13	Gill Ranch, *Madera*	1943	2,500	960	124	86	6	2	0	6
14	Goleta, *Santa Barbara*	1929	200	1,055	15,425	46	7	1	0	7
15	Honker, *Solano*	1944	500	x	14	14	1	1	0	1
16	Kirby Hills, *Solano*	1944	500	x	0	0	1	1	0	1
17	Lodi, *San Joaquin*	1943	1,000	770	54	0	5	0	0	5
18	Marysville-Buttes, *Sutter*	1936	2,000	1,000	6,555	857	5	0	0	4
19	McDonald Island, *San Joaquin*	1936	1,900	980	66,739	9,851	6	0	0	6
20	Moffat, *Madera*	1943	400	960	0	0	1	0	0	1
21	Ord Bend, *Glenn*	1943	750		0	0	2	2	0	1
22	Paloma (Buena Vista), *Kern*	1934	1,200	1,000	4,752	136	2	1	0	2
23	Rio Vista, *Sacramento and Solano*			(1,040)	(398,574)	(156,553)	(82)	(19)	(0)	(82)
24	Emigh Zone	1936	25,000				71			71
25	Midland Zone	1943	5,000				5			5
26	Hamilton Zone	1944	10,000				5			5
27	Anderson Zone	1944	3,000				1			1
28	Roberts Island, *San Joaquin*	1942	200	1,040	1,234	600	1	0	0	1
29	Santa Fe Springs, *Los Angeles*	1919	40	980	8,279	64	1	0	0	1
30	Semi Tropic, *Kern*	1932	3,825	980	8,188	979	22	0	0	13
31	Suisun Bay, *Solano*	1944	1,000	x	9	9	2	2	0	2
32	Thornton, Sacramento and San Joaquin	1943	3,400	780	6	4	5	2	0	5
33	Tompkins Hill, *Humboldt*	1937	520	1,040	1,470	717	4	0	0	4
34	Tracy, *San Joaquin*	1935	640	900	10,789	59	6	0	0	2
35	Trico, *Kern*	1935	7,500	980	19,987	4,526	32	0	0	25
36	Vernalis, Stanislaus and San Joaquin	1941	600	900	3,175	1,275	2	0	0	2
37	Willows, *Glenn*	1938	200	990	24	24	2	0	0	1

pleted in 1944. The large development program contemplated for the coming year will be dependent, of course, upon wartime requirements and conditions. Inasmuch as the year 1944 witnessed the drilling of the world's deepest test with several deep tests in critical areas already under way, it will not be surprising if additional deep-zone production and reserves are encountered in the coming year.

The demand for California crude oil is expected to continue, perhaps even above the record 1944 year. As has been well recognized, the demand for petroleum as a critical wartime requirement has put a real burden and drain upon the California oil industry, which undoubtedly will have to be augmented by the transportation of crude oils from other producing areas.

From the fact that only about two thirds of the oil produced in 1944 was offset in the form of added reserves through one sort or another, it is easy to assume that the figures recently quoted by Mr. Schilthuis—

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Producing Formation							Deepest Zone Tested to End of 1944	
	Initial	Avg. at End of 1944		Name and Age	Character[f]	Porosity[g]	Depth, Avg. Ft.: Top Prod. Zone	Depth, Avg. Ft.: Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
Gas Fields												
1	1,075	1,075		Cretaceous	S	31	2,648		12	A	Cretaceous	5,247
2	x	x		Pleistocene	S	x	3,425		85	A	Pliocene	3,630
3	1,700	1,500		Etchegoin, Pli	S	30	4,300		20	A	Miocene	12,138
4	x	200		San Joaquin clays, Pli	S	x	1,700		50	A	Miocene	14,622
5	1,000	550		Etchegoin, Pli	S	x	2,500		18	D	Pliocene	4,946
6	1,900	1,900		Cretaceous	S	x	4,365		25	A	Basement	7,005
7	2,100	x		Etchegoin, Pli	S	x	5,200		30	MU	Miocene	16,246
8	x	x		Cretaceous	S	x	4,070		x	A	Cretaceous	9,245
9	1,863	1,863		Eocene	S	x	4,575		x	A	Cretaceous	9,434
10	x	250 / 400		San Joaquin clays, Pli	S	38	1,800		75	A	Miocene	11,177
11	2,000	x		Pliocene	S	x	2,193		20	D	Franciscan Schist	8,009
12	1,590	1,400		Eocene(?)	S	x	3,651		30	A	Cretaceous	5,181
13	1,950	1,950		Eocene	S	30	4,460		29	AF	Cretaceous	9,154
14	1,800	x		Vaqueros, Mio	S	x	4,139		354	AF	Eocene	6,912
15	1,360	1,360		Eocene	S	x	3,409		x	A	Cretaceous (?)	8,304
16	1,128	1,128		Eocene	S	x	2,140		x	A	Eocene	2,617
17	1,110	1,110		Ione, Eoc	S	x	2,410		15	A	Granite	4,471
18	2,950	2,500		Cretaceous	S	28	2,700		87	MU	Igneous	6,900
19	2,280	2,000		Capay, Eoc	S	30	6,178		29	D	Cretaceous	8,810
20	1,710	1,710		Eocene	S	30	3,895		40	A	Eocene	4,308
21	1,480	1,480		Cretaceous	S	x	3,659		20	A	Cretaceous	6,346
22	1,660	1,200		Etchegoin, Pli	S	x	4,117		20	AS	Miocene	11,186
23						(35)						
24	1,708 / 1,593	1,442(W) / 1,367 (E)		Eocene	S		4,200(W) / 3,800 (E)		150(W) / 107(E)	AF		
25	2,000	1,836		Eocene	S		4,500		90	AF		
26	2,127	2,127		Eocene	S		5,565		130	AF	Cretaceous	7,029
27	2,220	2,220		Eocene	S		5,765		50	AF	Cretaceous	7,029
28	2,063	2,050		Capay, Eoc	S	x	5,240		10	A	Eocene	5,262
29	x	400		Repetto, Pli	S	x	2,500		20	D	Miocene	11,314
30	1,110	800		Etchegoin, Pli	S	25	2,275		6	A	Miocene	9,700
31	x	x		Eocene								
32	1,470	1,470		Ione, Eoc	S	x	3,375		5	A	Cretaceous	8,367
33	2,488	x		Repetto, Pli	Sh	26	3,800		170	A	Pliocene	7,708
34	1,750	900		Cretaceous	S	28	3,926		65	D	Cretaceous	9,690
35	1,157	x		Etchegoin, Pli	S	28	2,420		13	A	Miocene	11,468
36	1,620	1,360		Cretaceous	S	x	3,840		30	A	Cretaceous	3,872
37	675	675		Cretaceous	S	x	2,345		10	D	Cretaceous	6,014

indicating that there would be only about eleven years' supply left at the present rate of consumption—are not far wrong. A continuation of this demand will tend to obviate any serious curtailment at the conclusion of the war. It has been noticeable that the lack of skilled labor and the scarcity of materials is having its effect upon production. The continued drainage on manpower to meet the draft has likewise begun to show a detrimental effect upon the production of crude oil throughout the state.

Acknowledgments

Acknowledgment is made of the constructive criticism and assistance given by Capt. V. H. Wilhelm, and Messrs. R. M. Bauer, D. McCloskey, F. E. Minshall and E. K. Parks.

Oil and Gas Development in Illinois in 1944

By Alfred H. Bell,* Member A.I.M.E. and Virginia Kline*

In 1944, Illinois produced 77,413,000 bbl. of oil, or 4.6 per cent of the total for the United States, and continued to rank sixth in the nation in oil production. This represents a decrease of 6 per cent from 1943, when the total Illinois production was 82,256,000 bbl. This decrease was much less than the 23 per cent decrease in 1943 from production of the previous year. The principal factor in arresting the production decline, which had been going on since 1941, seems to be the increased drilling that followed the relaxing of the Federal Government's rules in regard to well spacing. The daily average production for 1944 was approximately 212,000 bbl. Daily averages by months were as follows:

Jan.	219,000	July	206,000
Feb.	220,000	Aug.	211,000
Mar.	216,000	Sept.	209,000
Apr.	211,000	Oct.	210,000
May	213,000	Nov.	209,000
June	209,000	Dec.	205,000

During the year, 1991 wells were drilled for oil and gas in Illinois as compared with 1791 in 1943, an increase of 11 per cent. Of the 1991 wells, 430 are classified as "wildcat" as compared with 461 in 1943. Twenty-eight new pools (Table 2*A*) were discovered in 1944 as compared with 29 in 1943. Changes in federal drilling regulations, permitting closer spacing of wells, resulted in a drilling program that emphasized development of proved acreage rather than wildcatting.

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Data on production and drilling by fields are given in Table 1; data on annual production and drilling for Illinois, in Table 3.

Discoveries

Twenty-eight new fields (Table 2*A*), 42 extensions (Table 2*B*), and 39 additional producing zones in existing fields (Table 2*C*) were discovered in 16 counties in Illinois during 1944. Of the 28 new fields, one was abandoned during the year, 14 were one-well fields, eight others had not more than 6 wells, one had 8, one had 9, one had 11, one had 15, and the largest new field, Roaches North, had 28 producing wells at the end of the year. In all, 109 wells were producing in these new fields on Jan. 2, 1945, as compared with 111 wells producing from 29 new fields at the end of 1943.

The average initial production of the discovery wells of the 28 new fields was 129 bbl. of oil and 11 bbl. of water, a notable decline from the average initial production of 194 bbl. of oil and 15 bbl. of salt water for the 1943 discovery wells.

In fields discovered since 1936, the total number of oil wells producing at the end of 1944 was 12,335.

Productive Acreage

The area of proved production in the new fields (discovered since 1936) increased from 144,335 acres at the end of 1943 to 173,485 acres at the end of 1944 (Table 1), an increase of 29,150 acres. Of this increased area, 1720 acres are in fields discovered during 1944 and 27,430 acres are in extensions of fields discovered earlier.

TABLE 1.—*Oil and Gas Production in Illinois*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
1	Warrenton-Borton, *Edgar*	1906	100	30,000	0		0	0	22	0	0
2	Westfield, *Clark, Coles*	1904	9,075	x	x		x	0	1,630	2	3
3			925	x	x		x	0	188	2	0
4			9,000	x	x		x	0	1,449	0	0
5			220	x	x		x	0	13	0	0
6	Siggins, *Cumberland, Clark*	1906	3,685	x	x		x	0	997	1	0
7			3,190	x	x		x	0	855	1	0
8			450	x	x		x	0	90	0	0
9			960	x	x		x	0	193	0	0
10	York, *Cumberland, Clark*	1907	350	x	x		x	0	70	0	0
11	Casey, *Clark*	1906	1,980	x	x		x	0	535	0	3
12			205	x	x		x	0	41	0	0
13			400	x	x		x	0	82	0	0
14			1,540	x	x		x	0	322	0	0
15	Martinsville, *Clark*	1907	865	x	x		x	0	219	0	2
16			35	x	x		x	0	7	0	0
17			310	x	x		x	0	64	0	0
18			710	x	x		x	0	23	0	0
19			600	x	x		x	0	35	0	0
20			640	x	x		x	0	40	0	0
21			10	x	x		x	0	2	0	0
22	Johnson North, *Clark*	1907	1,440	x	x		x	0	485	0	1
23			1,115	x	x		x	0	296	0	0
24			160	x	x		x	0	32	0	0
25			825	x	x		x	0	177	0	0
26			215	x	x		x	0	44	0	0
27	Johnson South, *Clark*	1907	1,800	x	x		x	x	544	8	22
28			190	x	x		x	x	38	0	0
29			295	x	x		x	x	59	0	0
30			1,710	x	x		x	x	411	8	0
31			850	x	x		x	x	170	0	0
32	Bellair, *Crawford, Jasper*	1907	1,305	x	x		x	x	486	0	0
33			1,165	x	x		x	x	310	0	0
34			315	x	x		x	x	65	0	0
35			910	x	x		x	x	182	0	0
36	Clark County Division[1]		20,500	54,242,000	386,000		x	x	4,966	11	31
37	Main,[2] *Crawford*	1906	35,650	x	x		x	x	7,324	0	181
38			340	x	x		x	x	68	0	0
39			34,305	x	x		x	x	7,143	0	0
40			1,000	x	x		x	x	108	0	0
41			10	x	x		x	x	1	0	0
42	New Hebron, *Crawford*	1909	1,560	x	x		x	x	297	0	4
43	Chapman, *Crawford*	1914	1,560	x	x		x	x	193	0	0
44	Parker, *Crawford*	1907	1,340	x	x		x	x	256	0	10
45	Allison-Weger, *Crawford*	x	1,100	x	x		x	x	149	1	13
46	Flat Rock,[3] *Crawford*	x	1,920	x	x		x	x	290	1	14
47	Birds, *Crawford, Lawrence*	x	4,485	x	x		x	x	684	0	44
48	Crawford County Division[4]		47,615	151,236,000	1,280,000		x	x	9,193	2	266
49	Lawrence, *Lawrence, Crawford*	1906	25,800	x	x		x	x	4,438	14	167
50			60	x	x		x	x	7	2	x
51			5,050	x	x		x	x	1,233	0	x
52			2,240	x	x		x	x	481	0	x
53			1,440	x	x		x	x	243	0	x
54			16,180	x	x		x	x	3,017	0	x
55			4,300	x	x		x	x	707	10	x
56			6,960	x	x		x	x	960	1	x
57			x	x	x		0	0			
58			x	x	x		0	0			
59			x	x	x		0	0			

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Total of lines 2, 6, 10, 11, 15, 22, 27, 32.
[2] Includes Kibbie, Oblong, Robinson, and Hardinsville.
[3] Includes Swearingen gas.
[4] Total of lines 37, 42, 43, 44, 45, 46, 47.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43]: Flowing	Oil[43]: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F[6]	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	0	0	0	x	x	W	x	x	Unnamed; Pen	S	P	159	x	ML	"Trenton"	2,212
2	0	290	0	293±	x		34.0	x						D	St. Peter	3,009
3	0	x	0	x	x		30.0	x	Shallow gas; Pen	S	P	281	40	D		
4	0	x	0	x	x		33.5	x	Westfield; MisL	L	Cav	334	x	DC		
5	0	x	0	x	x		38.2	0.18	"Trenton"; Ord	L	Cav	2,265	x	D		
6	0	801	0	x	x	P	33.0	x						D	Dev	2,010
7	0	x	0	x	x		34.0	x	First Siggins; Pen	S	P	367	x	D		
8	0	x	0	x	x		(33.6)	x	2nd & 3rd Siggins; Pen	S	P	478	x	D		
9	0	x	0	x	x		(25.7)	x	Lower Siggins; Pen	S	P	556	40	D		
10	0	0	0	x	x		(30.3)	x	York; Pen	S	P	588	x	AM	Pen	960
11	0	485	0	x	x	P	29.2	x						AM	MisL	808
12	0	x	0	x	x		(31.9)	x	Upper Gas; Pen	S	P	263	x	AM		
13	0	x	0	x	x		(30.1)	x	Lower Gas; Pen	S	P	309	x	AM		
14	0	x	0	x	x		(33.6)	x	Casey; Pen	S	P	444	40	AM		
15	0	114	0	x	x		36.8	x						D	St. Peter	3,411
16	0	x	0	x	x		x	x	Shallow; Pen	S	P	255	x	D		
17	0	x	0	x	x		x	x	Casey; Pen	S	P	500	x	D		
18	0	x	0	x	x		x	x	Martinsville; MisL	L	P	477	x	D		
19	0	x	0	x	x		(38.9)	x	Carper; MisL	S	P	1,340	x	D		
20	0	x	0	x	x		x	x	"Niagaran"; Dev	L	Cav	1,550	x	D		
21	0	x	0	x	x		(39.6)	x	"Trenton"; Ord	L	Cav	2,700	x	D		
22	0	432	0	x	x		31.0	x						AM	Mis	965
23	0	x	0	x	x		x	x	Claypool; Pen	S	P	416	x	AM		
24	0	x	0	x	x		x	x	Shallow; Pen	S	P	314	x	AM		
25	0	x	0	x	x		x	x	Casey; Pen	S	P	465	x	AM		
26	0	x	0	x	x		x	x	Upper Partlow; Pen	S	P	535	x	AM		
27	0	448	0	x	x	P	32.2	x						AM	Dev	2,030
28	0	x	0	x	x		x	x	Claypool; Pen	S	P	392	x	AM		
29	0	x	0	x	x		x	x	Casey; Pen	S	P	453	x	AM		
30	0	x	0	x	x		x	x	Upper Partlow; Pen	S	P	489	x	AM		
31	0	x	0	x	x		28.5	x	Lower Partlow; Pen	S	P	598	x	AM		
32	0	371	0	x	x	P	33.7	x						AM	MisL	1,471
33	0	x	0	x	x		(32.4)	x	"500 ft."; Pen	S	P	561	x	AM		
34	0	x	0	x	x		x	x	"800 ft."; Pen	S	P	817	x	AM		
35	0	x	0	x	x		(37.0)	x	"900 ft."; MisU	S	P	886	x	AM		
36	0	2,941	0	x	x		33.0	x							St. Peter	3,411
37	0	4,442	x	425±	x	P	33.0	x							St. Peter	4,654
38	0	x	x	x	x		x	x	Shallow; Pen	S	P	508	x	ML		
39	0	x	x	x	x		32.8	x	Robinson; Pen	S	P	900	25±	ML		
40	0	x	x	x	x		x	x	Oblong; Mis	SL	P	1,337	x	A, ML		
41	0	1	0	x	x		x	x	Devonian; Dev	L	P	2,794	11	ML		
42	0	142	0	x	x	P	30.1	x	Robinson; Pen	S	P	940	25	ML	Mis	2,056
43	0	60	0	x	x		x	x	Robinson; Pen	S	P	995	25	ML	Mis	2,279
44	0	199	0	x	x	P	29.5	x	Robinson; Pen	S	P	1,000	25	ML	Pen	1,127
45	0	54	0	x	x		22.5	x	Robinson; Pen	S	P	912	20	ML	Pen	1,041
46	0	112	x	x	x		31.8	x	Robinson (Flat Rock); Pen	S	P	935	x	ML	Dev	3,110
47	0	338	0	x	x	W	31.8	x	Robinson; Pen	S	P	930	28	ML	MisL	1,731
48	0	5,347	x	425±	x		32.3	x							St. Peter	4,654
49	0	2,927	0	650±	x		32.9	x						A	St. Peter	5,190
50	0	7	0	x	x		x	x	Pennsylvanian; Pen	S	P	290	x	A		
51	0	x	0	x	x		x	x	Bridgeport; Pen	S	P	800	40	A		
52	0	x	0	x	x		x	x	Buchanan; Pen	S	P	1,250	15	A		
53	0	x	0	x	x		x	x	"Gas"; MisU	S	P	1,330	15	A		
54	0	x	0	600±	x		x	x	Kirkwood; MisU	S	P	1,400	30	A		
55	0	x	0	650±	x		x	x	Tracey; MisU	S	P	1,560	20	A		
56	0	x	0	x	x		x	x	McClosky; MisL	L	P	1,700	10	A		
57				x	x		x	x	Aux Vases; MisU[25]	S	P	1,980	x	M		
58				x	x		x	x	Levias; MisL[25]	L	P	2,022	x	MC		
59				x	x		x	x	Rosiclare; MisL[25]	SL	P	2,038	x	MC		

[5] Pressures in Southeastern Illinois oil fields are estimated bottom-hole pressures reported in previous Survey publications.
[6] Gravities given prior to 1936 (except those in parentheses) were from data for the year 1925 furnished by the Ohio Pipe Line Co. (formerly called the Illinois Pipe Line Co.). Gravities in parentheses are for particular samples (see Ill. State Geological Survey *Bull.* 54, Table 3). The values have been converted from Baumé to A.P.I. gravities.
[25] Producing in combination wells only.
[43] Discrepancies between original completions and present producing wells in various pays are due to wells that were worked over.

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
60	St. Francisville, *Lawrence*	*x*	420	*x*	*x*		*x*	*x*	55	0	0
61	Lawrence County Division[7]		26,220	233,538,000	1,615,000		*x*	*x*	4,493	14	167
62	Allendale, *Wabash, Lawrence*	1912	2,600	7,139,000	800,000		*x*	*x*	545	17	5
63			*x*	*x*	*x*		*x*	*x*	*x*	*x*	*x*
64			*x*	*x*	*x*		*x*	*x*	*x*	*x*	*x*
65			*x*	*x*	*x*		*x*	*x*	473	6	0
66			*x*	*x*	*x*		*x*	*x*			
67			*x*	*x*	*x*		*x*	*x*	4	1	0
68			*x*	*x*	*x*		*x*	*x*	6	0	0
69			*x*	*x*	*x*		*x*	*x*	14	8	0
70			*x*	*x*	*x*		*x*	*x*	37	1	0
71			*x*	*x*	*x*		*x*	*x*	*x*	*x*	0
72			*x*	*x*	*x*		*x*	*x*	9	0	0
73	Total Southeastern Fields[8]		97,035	446,185,000	4,081,000		*x*	*x*	19,219	44	469
74	Ayers gas, *Bond*	1922	325	0	0		235.9	14.7	21	0	0
75	Greenville gas, *Bond*	1910[9]	160	0	0		990.0	0	4	0	0
76	Bartelso, *Clinton*	1936	580	1,479,000	123,000		0	0	73	0	3
77			320	916,000	55,000		0	0	48	0	3
78			230	563,000	68,000		0	0	25	0	0
79	Carlyle, *Clinton*	1911	915	3,509,000	28,000		0	0	165	0	0
80	Frogtown, *Clinton*	1918[10]	300	*x*	0		0	0	12	0	0
81	Ava-Campbell Hill, *Jackson*	1917[11]	440	*x*	0		*x*	0	35	0	0
82	Colmar-Plymouth, *McDonough, Hancock*	1914	2,450	3,099,000	108,000		0	0	486	0	0
83	Carlinville, *Macoupin*	1909[12]	80	*x*	1,000		*x*	0	8	0	0
84	Gillespie-Benld gas, *Macoupin*	1923[13]	80	0	0		135.8	0	4	0	0
85	Gillespie-Wyen, *Macoupin*	1915	40	*x*	3,000		0	0	22	0	0
86	Spanish Needle Creek gas, *Macoupin*	1915[14]	80	0	0		14.4	0	7	0	0
87	Staunton gas, *Macoupin*	1916[15]	400	0	0		1,050.0	0	18	0	0
88	Collinsville, *Madison*	1909[16]	40	850	0		0	0	6	0	0
89	Brown, Langewisch-Kuester, Junction City, *Marion*	1910	175	*x*	*x*		0	0	14	0	0
90			60	*x*	*x*		0	0	7	0	0
91			115	*x*	*x*		0	0	7	0	0
92	Sandoval, *Marion*	1909	770	5,155,000	96,000		0	0	150	0	2
93			770	2,702,000	2,000		0	0	123	0	0
94			380	2,452,000	93,000		0	0	27	0	2
95	Wamac, *Marion, Clinton, Washington*	1921	250	479,000	10,000		0	0	106	0	0
96	Litchfield, *Montgomery*	1879[17]	100	22,900	100		0	0	18	0	0
97	Waterloo, *Monroe*	1920[18]	230	226,000	2,000		0	0	41	0	0
98	Jacksonville gas, *Morgan*	1910[19]	1,320	2,000	0		*x*	0	53	0	0
99	Pittsfield gas, *Pike*	1886[20]	8,960	0	0		*x*	0	68	0	0
100	Sparta, *Randolph*	1888[21]	165	*x*	0		*x*	0	20	0	0
101	Dupo, *St. Clair*	1928	670	1,894,000	15,000		*x*	0	299	4	1
102	Total of fields discovered prior to Jan. 1, 1937[22]		115,565	461,361,000	4,467,000		2,426.1	14.7	20,894	48	475
103	Beaver Creek, *Bond*	1942	140	26,000	19,000		0	0	9	7	0
104	Sorento, *Bond*	1938[23]	30	4,000	0		0	0	3	0	0
105	Woburn, *Bond*	1940	210	447,000	42,000		0	0	28	0	0

[7] Total of lines 49 and 60.
[8] Total of lines 1, 36, 48, 61, 62.
[9] Abandoned 1923.
[10] Abandoned 1933.
[11] Abandoned 1934.
[12] Abandoned 1925, revived 1942.
[13] Abandoned 1935.
[14] Abandoned 1934.
[15] Abandoned 1919.
[16] Abandoned 1921.
[17] Abandoned 1904, revived 1942, abandoned 1944.
[18] Abandoned 1930, revived 1939.
[19] Abandoned 1937.
[20] Gas not used until 1905, abandoned 1930.
[21] Abandoned 1900.
[22] Total of lines 66 to 94 inclusive. Cumulative oil production total based on U. S. Bureau of Mines monthly report.
[23] Abandoned 1944.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43]: Flowing	Wells Producing[g] Dec. 1944: Oil[43]: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Reservoir Pressure, Lb. per Sq. In.[5]: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F[6]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[f]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole Ft
60	0	30	0	600	x		37.3	x	Bethel; MisU	S	P	1,843	22	ML	Mis	1,900
61	0	2,957	0	x	x										St. Peter	5,190
62	0	307	0			W									MisL	2,367
63	0	x	0	x	x		x	x	Bridgeport; Pen	S	P	1,069	12	AM		
64	0	x	0	x	x		x	x	Buchanan; Pen	S	P	1,290	15	AM		
65	0	155	0	x	x		35.1	x	Biehl; Pen	S	P	1,425	20	AM		
66				x	x		x	x	Jordan;[25] Pen	S	P	1,490	10	AM		
67	0	1	0	x	x		x	x	Waltersburg; MisU	S	P	1,540	15	AL		
68	0	6	0	x	x		x	x	Tar Springs; MisU	S	P	1,600	20	AM		
69	0	14	0	x	x		x	x	Cypress; MisU	S	P	1,920	10	AM		
70	0	34	0	x	x		x	x	Bethel; MisU	S	P	2,010	10	AM		
71	0	x	0	x	x		x	x	Rosiclare; MisU	SL	P	2,230	5	AM		
72	0	9	0	900	x		x	x	McClosky; MisL	L	P	2,280	8	AM		
73	0	11,525	x													
74	0	0	9	335	x				Bethel, MisU	S	P	940	5	A	"Trenton"	3,044
75	0	0	0	x					Lindley (1st, 2nd); MisU	S	P	927	x	A	Dev	2,290
76	0	62	0											D	St. Peter	4,212
77	0	39	0	x	x		36.2	0.20	Carlyle; MisU	S	P	984	24	D		
78	0	23	0	x	x		41.5	0.27	Devonian; Dev	L	Cav	2,420	9	D		
79	0	26	0	x	x		35.2	0.26	Carlyle; MisU	S	P	1,035	20	A	St. Peter	4,120
80	0	0	0	x	x		31.9	x	Carlyle; MisU	S	P	950	7	A	Cypress	962
81	0	0	0	x	x		x	x	Cypress; MisU	S	P	780	18	A	Dev	2,530
82	0	228	0	x	x		37.6	0.38	Hoing; Dev	S	P	450	21	AL	"Trenton"	805
83	0	4	0	135	x		27.7	x	Unnamed; Pen	S	P	380	x	A	Pen	410
84	0	0	0	155					Unnamed; Pen	S	P	542	x	A	Pen	575
85	0	8	0	x	x		30.0	x	Unnamed; Pen	S	P	650	x	T	"Trenton"	2,560
86	0	0	0	x					Unnamed; Pen	S	P	305	x	D	Pen	495
87	0	0	0	145					Unnamed; Pen	S	P	461	x	A	"Trenton"	2,371
88	0	0	0	x			x	x	Dev-Sil	L	Cav	1,305	20	ML	Sil	1,500
89	0	5	0													
90	0	x	0	x	x		32.0	x	Dykstra, Wilson; Pen	S	P	610	20	D	MisL	2,001
91	0	x	0	x	x		32.0	x	Cypress; MisU	S	P	1,658	15	D	Dev	3,344
92	0	22	0											D	St. Peter	5,023
93	0	8	0	x	x		34.5	x	Benoist; MisU	S	P	1,540	20±	D		
94	0	15	0	x	x		38.0	0.38	Devonian; Dev	L	Cav	2,924	9	D		
95	0	20	0	x	x		30.2	x	Petro; Pen	S	P	720	20	D	MisL	1,760
96	0	1	0	x	x		23.0	0.42	Unnamed; Pen	S	P	664	x	D	Pen	681
97	0	4	0	x	x		30.2	0.79	"Trenton"; Ord	L	Cav	410	50	A	"Trenton"	845
98	0	0	0	x	x		x	x	Gas; Pen, MisL	S, SL	P	330	5	ML	"Trenton"	1,390
99	0	0	0	x					"Niagaran"; Sil	L	P	265	10	A	St. Peter	893
100	0	0	0	x			x	x	Cypress; MisU	S	P	850	7	D	MisU	985
101	0	88	0	x	x		32.7	0.70	"Trenton"; Ord	L	Cav	561	50	A	New Richmond	1,800
102	0	12,020	x													
103	0	9	0	x	x		34.2	0.25	Benoist; MisU	S	P	1,180	8	A	Dev	2,526
104	0	0	0	x			35.4	x	Devonian; Dev	L	P	1,830	5	A	Dev	1,900
105	0	28	0	x	x		36.4	0.20	Benoist; MisU	S	P	1,010	11	A	Dev	2,476

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
106	Mt. Auburn, *Christian*	1943	40	7,000	4,000		0	0	1	0	0
107	Bible Grove East, *Clay*	1944	20	*x*	*x*		0	0	2	2	0
108	Bible Grove South, *Clay*	1942	20	27,000	9,000		0	0	1	0	0
109	Clay City West, *Clay*	1941	360	1,018,000	60,000		0	0	15	1	0
110	Flora, *Clay*	1938	640	589,000	135,000		0	0	32	4	0
111			10	*x*	*x*		0	0	1	0	0
112			*x*	*x*	*x*		0	0	3	0	0
113			*x*	*x*	*x*		0	0	2	0	0
114			*x*	*x*	*x*		0	0			
115			*x*	*x*	*x*		0	0	23	3	0
116									3	1	0
117	Ingraham, *Clay*	1942[24]	80	3,000	500		0	0	2	0	1
118	Iola, *Clay*	1939[27]	2,000	2,100,000	1,079,000		0	0	101	25	0
119			*x*	*x*	*x*		0	0			
120			*x*	*x*	*x*		0	0	8	4	0
121			*x*	*x*	*x*		0	0	4	0	0
122			*x*	*x*	*x*		0	0	53	19	0
123			*x*	*x*	*x*		0	0	8	0	0
124			*x*	*x*	*x*		0	0			
125			*x*	*x*	*x*		0	0			
126			*x*	*x*	*x*		0	0			
127									28	2	0
128	Kenner, *Clay*	1942	520	102,000	90,000		0	0	25	17	0
129			*x*	*x*	*x*		0	0	1	0	0
130	Sailor Springs Consolidated, *Clay*	1941	2,180	1,647,000	520,000		0	0	102	31	2
131			*x*	*x*	*x*		0	0			
132			*x*	*x*	*x*		0	0	36	5	1
133			*x*	*x*	*x*		0	0	63	24	0
134			*x*	*x*	*x*		0	0	5	0	1
135									4	3	0
136	Sailor Springs East, *Clay*	1944	160	9,000	9,000		0	0	9	9	0
137	Toliver, *Clay*	1942[28]	40	6,000	1,000		0	0	1	0	1
138	Toliver East, *Clay*	1943	60	68,000	57,000		0	0	3	2	0
139	Xenia, *Clay*	1941	40	14,000	3,000		0	0	1	0	0
140	Bible Grove, *Clay, Effingham*	1942	2,400	2,089,000	1,049,000		0	0	122	54	1
141			*x*	*x*	*x*		0	0	114	54	0
142			*x*	*x*	*x*		0	0	8	0	1
143	Clay City Consolidated, *Clay, Wayne*	1937	21,000	35,873,000	5,111,000		0	0	957	165	6
144			*x*	*x*	*x*		0	0	34	2	0
145			*x*	*x*	*x*		0	0	1	0	0
146			*x*	*x*	*x*		0	0	127	90	0
147			*x*	*x*	*x*		0	0	6	1	0
148			*x*	*x*	*x*		0	0	750	68	5
149									19	4	0
150	Bartelso South, *Clinton*	1942	80	10,000	3,000		0	0	2	0	0
151	Boulder, *Clinton*	1941	360	1,536,000	535,000		*x*	*x*	35	0	0
152			*x*	*x*	*x*		0	0	24	0	0
153			*x*	*x*	*x*		*x*	*x*	11	0	0
154	Centralia West, *Clinton*	1940	90	213,000	48,000		0	0	10	0	0
155	Hoffman, *Clinton*	1939	300	481,000	50,000		0	0	44	0	2
156			*x*	*x*	*x*		0	0	10	0	*x*
157			*x*	*x*	*x*		0	0	34	0	*x*
158	Posey, *Clinton*	1941	20	5,000	500		0	0	2	0	0
159	Santa Fe, *Clinton*	1944	10	100	100		0	0	1	1	0
160	Centralia, *Clinton, Marion*	1937	2,850	25,806,000	1,740,000		0	0	906	0	45
161			*x*	*x*	*x*		0	0	23	0	*x*
162			*x*	*x*	*x*		0	0	562	0	*x*
163			*x*	*x*	*x*		0	0	0	0	0
164			*x*	15,250,000	1,015,000		0	0	319	0	*x*
165			*x*	31,000	3,000		0	0	2	0	0
166	Cooks Mills, *Coles*	1941	20	5,000	400		0	0	2	0	1

[24] Abandoned 1942, revived 1943, abandoned 1944.
[27] Abandoned 1940, revived 1941.
[28] Abandoned 1944.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43] Flowing	Oil[43] Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.[6]	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
106	0	1	0	x	x		36.6	0.28	Silurian; Sil	L	P	1,900	4	x	Sil	1,998
107	0	2	0	x	x		x	x	Cypress; MisU	S	P	2,510	10	A	MisU	2,539
108	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	2,750	10	ML	MisL	2,946
109	0	15	0	x	x		39.0	0.17	McClosky; MisL	OL	P	3,050	15	A	MisL	3,080
110	0	26	0												MisL	3,100
111	0	0	0	x	x		x	x	Tar Springs; MisU	S	P	2,320	12	A		
112	0	1	0	x	x		x	x	Cypress; MisU	S	P	2,595	5	A		
113	0	2	0	x	x		37.4	x	Bethel; MisU	S	P	2,790	20	A		
114				x	x		x	x	Aux Vases; MisU[25]	S	P	2,875	28	A		
115	0	20	0	x	x		37.2	0.24	McClosky; MisL	OL	P	2,970	6	A		
116	0	3	0						[26]							
117	0	0	0	x	x		x	x	McClosky; MisL	OL	P	3,100	7	MC	MisL	3,140
118	0	99	0												MisL	2,590
119				x	x		x	x	Tar Springs; MisU[25]	S	P	1,890	9	D		
120	0	8	0	x	x		x	x	Weiler; MisU	S	P	2,125	20	D		
121	0	4	0	x	x		36.0	0.14	Bethel; MisU	S	P	2,290	14	D		
122	0	51	0	x	x		35.4	0.25	Aux Vases; MisU	S	P	2,335	11	D		
123	0	8	0	x	x		x	x	McClosky; MisL	OL	P	2,425	10	ML		
124				x	x		x	x	Paint Creek; MisU[25]	S	P	2,240	15	D		
125				x	x		x	x	Renault; MisU[25]	S	P	2,320	9	D		
126				x	x		x	x	Rosiclare; MisL[25]	SL	P	2,410	7	D		
127	0	28	0						[26]							
128	0	23	0	x	x		36.8	0.22	Bethel; MisU	S	P	2,660	10	AC	MisL	3,035
129	0	1	0	x	x		x	x	Aux Vases; MisU[25]	S	P	2,810	9	A		
130	0	101	0												MisL	3,460
131				x	x		x	x	Glen Dean; MisU[25]	L	P	2,390	8	A		
132	0	30	0	x	x		39.5	0.17	Tar Springs; MisU	S	P	2,340	15	A		
133	0	63	0	775	x		38.5	0.28	Cypress; MisU	S	P	2,590	14	A		
134	0	4	0	x	x		36.4	x	McClosky; MisL	OL	P	3,000	5	A		
135	0	4	0						[26]						MisU	2,718
136	0	9	0	x	x		29.0	x	Cypress; MisU	S	P	2,690	8	D	MisL	2,890
137	0	0	0	x	x		37.1	x	McClosky; MisL	OL	P	2,790	10	MC	MisL	2,946
138	0	3	0	x	x		x	x	McClosky; MisL	OL	P	2,840	8	MC	Dev	4,970
139	0	1	0	x	x		35.2	0.19	Aux Vases; MisU	S	P	2,785	12	A	MisL	2,970
140	0	119	0													
141	0	112	0	x	x		38.0	0.13	Weiler; MisU	S	P	2,490	15	A		
142	0	7	0	x	x		36.2	x	McClosky; MisL	OL	P	2,810	6	A	Dev	4,840
143	0	918	0			W										
144	0	42	0	x	x		37.9	x	Cypress; MisU	S	P	2,670	10	A		
145	0	0	0	x	x		38.0	x	Bethel; MisU[25]	S	P	2,880	5	A		
146	0	126	0	x	x		38.0	x	Aux Vases; MisU	S	P	2,910	15	AL		
147	0	6	0	x	x		38.0	x	Rosiclare; MisL	OL	P	2,970	4	AL		
148	0	645	0	x	x		38.5	x	McClosky; MisL	OL	P	2,980	10	AM		
149	0	97	0						[26]						Dev	2,652
150	0	2	0	x	x		40.0	0.15	Devonian; Dev	L	Cav	2,465	8	A	Dev	2,672
151	1	31	3													
152	0	24	0	x	x		36.0	x	Bethel; MisU	S	P	1,190	20	A		
153	1	7	3	x	x		28.2	0.33	Devonian; Dev	L	Cav	2,630	4	A	MisU	1,531
154	0	9	0	x	x		37.8	0.17	Bethel; MisU	S	P	1,410	8	N	Dev	2,914
155	0	34	0													
156	0	x	0	x	x		x	x	Cypress; MisU	S	P	1,885	11	A		
157	0	x	0	x	x		32.2	0.21	Bethel; MisU	S	P	1,320	7	A	MisU	1,265
158	0	1	0	x	x		36.1	0.17	Cypress; MisU	S	P	1,100	5	M	Dev	2,512
159	0	1	0	x	x		x	x	Weiler; MisU	S	P	950	19	x	"Trenton"	4,070
160	0	509	0													
161	0	x	0	x	x		36.4	0.20	Cypress; MisU	S	P	1,200	15	A		
162	0	x	0	x	25±		37.7	0.17	Bethel; MisU	S	P	1,355	20	A		
163	0	2	0	x	x		x	x	McClosky; MisL	OL	P	x	x	A		
164	0	250	0	x	200±		37.4	0.38	Devonian; Dev	L	Cav	2,870	12	A		
165	0	1	0	x	x		43.2	0.28	"Trenton"; Ord	L	Cav	4,020	7	A		
166	0	1	0	x	x		36.4	0.40	Aux Vases; MisU	S	P	1,825	10	M	Dev	3,226

[26] Wells producing from more than one sand, see Table 6.

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
167	Mattoon, *Coles*	1939[29]	320	61,000	28,000		0	0	11	8	0
168			10	*x*	*x*		0	0	2	1	0
169			290	*x*	*x*		0	0	8	7	0
170			20	*x*	*x*		0	0	1	0	0
171	New Bellair, *Crawford*	1942	20	9,000	2,000		0	0	2	0	0
172	Albion Consolidated, *Edwards*	1940	3,000	3,534,000	818,000		0	0	153	62	0
173			*x*	*x*	*x*		0	0	2	2	0
174			*x*	*x*	*x*		0	0	7	1	0
175			*x*	*x*	*x*		0	0	10	10	0
176			*x*	*x*	*x*		0	0			
177			*x*	*x*	*x*		0	0	22	8	0
178			*x*	*x*	*x*		0	0			
179			*x*	*x*	*x*		0	0	1	1	0
180			*x*	*x*	*x*		0	0	4	1	0
181			*x*	*x*	*x*		0	0	1	1	0
182			*x*	*x*	*x*		0	0	11	9	0
183			*x*	*x*	*x*		0	0	2	2	0
184			*x*	*x*	*x*		0	0	1	1	0
185			*x*	*x*	*x*		0	0	66	5	0
186									27	21	0
187	Albion East, *Edwards*	1943	320	183,000	148,000		0	0	11	5	0
188			*x*	*x*	*x*		0	0	4	3	0
189			*x*	*x*	*x*		0	0			
190			*x*	*x*	*x*		0	0			
191			*x*	*x*	*x*		0	0	[illegible]	0	0
192			*x*	*x*	*x*		0	0	1	0	0
193			*x*	*x*	*x*		0	0			
194									3	2	0
195	Bennington South, *Edwards*	1944	20	6,000	6,000		0	0	1	1	0
196	Bone Gap, *Edwards*	1941	360	587,000	115,000		0	0	19	1	2
197	Browns South, *Edwards*	1943	20	1,000	1,000		0	0	[illegible]	1	1
198	Cowling, *Edwards*	1939	220	321,000	24,000		0	0	15	2	0
199			*x*	*x*	*x*		0	0	13	0	0
200			*x*	*x*	*x*		0	0			
201			*x*	*x*	*x*		0	0	[illegible]	2	0
202									[illegible]	0	0
203	Ellery North, *Edwards*	1942[30]	20	3,000	0		0	0	1	0	0
204	Ellery South, *Edwards*	1943	80	18,000	11,000		0	0	[illegible]	0	1
205	Maplegrove, *Edwards*	1943	520	542,000	318,000		0	0	17	4	0
206	Maplegrove East, *Edwards*	1944	120	12,000	12,000		0	0	3	3	0
207	Samsville, *Edwards*	1942[31]	20	700	0		0	0	1	0	0
208	Browns, *Edwards, Wabash*	1943	560	1[illegible]6,000	1[illegible],000		0	0	18	17	0
209			*x*	*x*	*x*		0	0	4	3	0
210			*x*	*x*	*x*		0	0	1	1	0
211			*x*	*x*	*x*		0	0	8	8	0
212									5	5	0
213	Lancaster West, *Edwards, Wabash*	1943	80	77,000	29,000		0	0	3	1	0
214			*x*	*x*	*x*		0	0	2	1	0
215			*x*	*x*	*x*		0	0	1	0	0
216	Bennington, *Edwards, Wayne*	1943	80	33,000	21,000		0	0	4	2	0
217			*x*	*x*	*x*		0	0	3	1	0
218			*x*	*x*	*x*		0	0	1	1	0
219	Ellery, *Edwards, Wayne*	1941	40	37,000	7,000		0	0	2	0	0
220			20	*x*	*x*		0	0			
221			20	*x*	*x*		0	0	2	0	0
222									0	0	0
223	Grayville, *Edwards, White*	1939	300	422,000	103,000		0	0	24	4	1
224			*x*	*x*	*x*		0	0	1	1	0
225			*x*	*x*	*x*		0	0	1	1	0
226			*x*	*x*	*x*		0	0	1	1	0
227			*x*	*x*	*x*		0	0	20	0	1
228									1	0	0

[29] Abandoned 1939, revived 1940.
[30] Abandoned 1943.
[31] Abandoned 1942.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43]: Flowing	Wells Producing[g] Dec. 1944: Oil[43]: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Reservoir Pressure, Lb. per Sq. In.[5]: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.[6]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
167	0	9	0												Shakopee	4,915
168	0	0	0	x	x		44.1	0.16	Cypress; MisU	S	P	1,835	15	D		
169	0	8	0	x	x		x	x	Rosiclare; MisL	S	P	2,000	10	ML		
170	0	1	0	x	x		36.6	0.29	McClosky; MisL	OL	P	2,025	12	D		
171	0	2	0	x	x		x	x	Pennsylvanian; Pen	S	P	1,170	30	ML	Dev	2,760
172	0	146	0												Dev	5,185
173	0	1	0	x	x		29.6	x	Mansfield; Pen	S	P	1,650	13	MF		
174	0	5	0	550	x		34.0	x	Bridgeport; Pen	S	P	1,860	20	MF		
175	0	10	0	600	x		x	x	Biehl; Pen	S	P	1,995	15	MF		
176				600	x		x	x	Degonia; MisU[25]	S	P	2,125	8	MF		
177	0	21	0	400	x		34.0	x	Waltersburg; MisU	S	P	2,365	15	AL		
178				700	x		x	x	Tar Springs; MisU[25]	S	P	2,450	10	AL		
179	0	1	0	x	x		x	x	Hardinsburg; MisU	S	P	2,364	5	A		
180	0	5	0	900	x		38.0	x	Bethel; MisU	S	P	2,960	15	Af		
181	0	1	0	900	x		x	x	Renault; MisU	S	P	3,002	10	Af		
182	0	11	0	950	x		39.0	x	Aux Vases; MisU	S	P	3,045	20	Af		
183	0	2	0	x	x		x	x	Levias; MisL	L	P	3,110	10	A		
184	0	1	0	x	x		x	x	Rosiclare; MisL	L	P			A		
185	0	58	0	900	x		40.0	0.18	McClosky; MisL	L	P	3,140	10	AC		
186	0	30	0						26							
187	0	11	0												MisL	3,244
188	0	4	0	x	x		x	x	Cypress; MisU	S	P	2,790	15	A		
189				x	x				Paint Creek; MisU[25]	S	P	2,910	10	A		
190				x	x				Bethel; MisU[25]	S	P	2,955	25	A		
191	0	3	0	x	x		x	x	Aux Vases; MisU	S	P	3,000	15	A		
192	0	1	0	x	x		x	x	Levias; MisL	L	P	3,100	6	A		
193				x	x		x	x	McClosky; MisL[25]	L	P	3,140	8	A		
194	0	3	0						26							
195	0	1	0	x	x		x	x	McClosky; MisL	L	P	3,253	4	MC	MisL	3,419
196	0	16	0	x	x		40.5	0.33	McClosky; MisL	L	P	3,250	10	A	MisL	3,350
197	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,840	15	L	MisL	3,144
198	0	13	0												MisL	3,175
199	0	9	0	x	x		36.6	0.23	Cypress; MisU	S	P	2,630	15	A		
200				x	x		x	x	Bethel; MisU[25]	S	P	2,770	x	AL		
201	0	2	0	x	x		x	x	McClosky MisU	L	P	2,995	5	AC		
202	0	2	0						26							
203	0	0	0	x	x		37.6	0.19	McClosky; MisL	L	P	3,420	7	MC	MisL	3,496
204	0	1	0	225±	x		39.0	x	McClosky; MisL	L	P	3,320	11	MC	MisL	3,373
205	0	14	0	x	x		x	x	McClosky; MisL	L	P	3,270	8	A	MisL	3,340
206	0	3	0	x	x		x	x	McClosky; MisL	L	P	3,215	6	ML	MisL	3,315
207	0	0	0	x	x		x	x	Waltersburg; MisU	S	P	2,430	4	x	MisL	3,295
208	0	18	0												MisL	3,187
209	0	6	0	x	x		x	x	Cypress; MisU	S	P	2,651	30	AL		
210	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,778	12	A		
211	0	5	0	x	x		x	x	McClosky; MisL	L	P	3,007	9	A		
212	0	6	0						26							
213	0	3	0												MisL	3,125
214	0	2	0	x	x		x	x	Levias; MisL	L	P	2,850	8	MC		
215	0	1	0	x	x		x	x	McClosky; MisL	L	P	2,860	8	MC		
216	1	3	0												MisL	3,350
217	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	3,150	20	ML		
218	1	2	0	x	x		x	x	McClosky; MisL	L	P	3,215	10	MC		
219	0	2	0												MisL	3,365
220				x	x		x	x	Aux Vases; MisU[25]	S	P	3,242	20	AL		
221	0	1	0	x	x		39.1	x	McClosky; MisL	L	P	3,340	10	A		
222	0	1	0						26							
223	0	18	0												MisL	3,280
224	0	1	0	x	x		x	x	Palestine; MisU	S	P	2,098	12	AL		
225	0	1	0	x	x		x	x	Cypress; MisU	S	P	2,888	16	A		
226	0	1	0	x	x		x	x	Rosiclare; MisL	L	P	3,122	x	A		
227	0	14	0	x	x		35.8	0.31	McClosky; MisL	L	P	3,100	10	A		
228	0	1	0						26							

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	1944: Completed	1944: Abandoned
229	Hill, *Effingham*	1943	40	24,000	16,000		0	0	2	0	0
230	Mason, *Effingham*	1940	100	171,000	10,000		0	0	9	0	1
231	Mason South, *Effingham*	1941	700	655,000	221,000		0	0	45	3	1
232			x	x	x		0	0	19	0	1
233			x	x	x		0	0	4	1	0
234			x	x	x		0	0	4	1	0
235			x	x	x		0	0	3	0	0
236									15	1	0
237	Louden, *Effingham, Fayette*	1937	20,650	112,607,000	11,271,000		0	0	1,987	1	15
238			20,080	x	x		0	0	949	1	1
239			11,000	x	x		0	0	323	0	1
240			7,010	x	x		0	0	420	0	0
241			3,130	5,862,000	1,599,000		0	0	84	0	1
242									211	0	12
243	La Clede, *Fayette*	1943	40	2,000	2,000		0	0	1	0	0
244	St. James, *Fayette*	1938	1,900	7,703,000	921,000		0	0	192	1	6
245	St. Paul, *Fayette*	1941	170	240,000	65,000		0	0	13	0	0
246	Akin, *Franklin*	1942	140	208,000	67,000		0	0	7	0	0
247			x	x	x		0	0	3	0	0
248			x	x	x		0	0	3	0	0
249			x	x	x		0	0			
250									1	0	0
251	Benton, *Franklin*	1941	2,200	16,268,000	1,558,000		0	0	243	9	4
252	Benton North, *Franklin*	1941	200	266,000	66,000		0	0	15	3	0
253			x	x	x		0	0	1	1	0
254			x	x	x		0	0	4	1	0
255			x	x	x		0	0	2	0	0
256			x	x	x		0	0	2	0	0
257			x	x	x		0	0	1	0	0
258			x	x	x		0	0	1	0	0
259			x	x	x		0	0	2	0	0
260									2	1	0
261	Bessie, *Franklin*	1943	20	15,000	7,000		0	0	1	0	0
262	Ewing, *Franklin*	1944	40	3,000	3,000		0	0	1	1	0
263	Sesser, *Franklin*	1942	60	46,000	16,000		0	0	5	1	0
264			x	x	x		0	0	4	0	0
265			x	x	x		0	0			
266			x	x	x		0	0			
267									1	1	0
268	Thompsonville, *Franklin*	1940	220	258,000	17,000		0	0	19	0	2
269	Thompsonville North, *Franklin*	1944	10	x	x		0	0	1	1	0
270	Valier, *Franklin*	1942	20	2,000	1,000		0	0	1	0	0
271	West Frankfort, *Franklin*	1941	150	403,000	268,000		0	0	15	5	0
272			x	x	x		0	0	14	5	0
273			x	x	x		0	0	1	0	0
274	West Frankfort South, *Franklin*	1943	100	156,000	102,000		0	0	8	0	0
275			x	x	x		0	0	6	0	0
276			x	x	x		0	0	2	0	0
277	Whittington, *Franklin*	1939	120	45,000	15,000		0	0	3	1	0
278			x	x	x		0	0	1	0	0
279			x	x	x		0	0			
280			x	x	x		0	0	1	1	0
281									1	0	0
282	Whittington West, *Franklin*	1943	60	5,000	5,000		0	0	3	2	0
283			x	x	x		0	0	2	2	0
284			x	x	x		0	0	1	0	0
285	Inman, *Gallatin*	1940	60	60,000	13,000		0	0	8	0	0
286			x	x	x		0	0	3	0	0
287			x	x	x		0	0	2	0	0
288			x	x	x		0	0	2	0	0
289			x	x	x		0	0	1	0	0
290	Inman East, *Gallatin*	1940	1,060	2,560,000	868,000		0	0	98	17	0
291			x	x	x		0	0	3	0	0
292			x	x	x		0	0			
293			x	x	x		0	0	1	1	0

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.[5]		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Oil[43] Flowing	Oil[43] Artificial Lift	Gas	Initial	Avg./End 1944		Gravity A.P.I. at 60°F[6]	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
229	0	2	0	*x*	*x*		39.0	*x*	McClosky; MisL	L	P	2,570	6	A	MisL	2,675
230	0	2	0	*x*	*x*		38.4	0.21	McClosky; MisL	L	P	2,490	14	A	MisL	2,551
231	0	43	0												MisL	2,553
232	0	17	0	*x*	*x*		38.0	*x*	Bethel; MisU	S	P	2,290	20	A		
233	0	4	0	*x*	*x*		*x*	*x*	Aux Vases; MisU	S	P	2,360	14	A		
234	0	4	0	*x*	*x*		*x*	*x*	Rosiclare; MisL	S	P	2,430	8	A		
235	0	3	0	*x*	*x*		38.4	0.21	McClosky; MisL	L	P	2,450	7	A		
236	0	15	0						26							
237	167	1,625	0			G									St. Peter	4,680
238	34	*x*	0	*x*	286±		36.6	0.25	Cypress; MisU	S	P	1,495	22	A		
239	0	*x*	0	*x*	315±		37.8	0.24	Paint Creek; MisU	S	P	1,538	15	A		
240	0	*x*	0	*x*	319±		38.5	0.20	Bethel; MisU	S	P	1,550	16	A		
241	23	59	0	*x*	1,268		28.2	0.48	Devonian; Dev	L	Cav	3,000	16	A		
242	111	553	0						26							
243	0	1	0	*x*	*x*		*x*	*x*	Bethel; MisU	S	P	2,335	20	T	MisL	2,608
244	0	178	0	*x*	*x*		34.4	0.31	Cypress; MisU	S	P	1,580	16	A	Dev	3,375
245	0	12	0	*x*	*x*		34.0	0.23	Bethel; MisU	S	P	1,885	6	A	Dev	3,570
246	0	7	0												MisL	3,515
247	0	3	0	*x*	*x*		32.0	*x*	Cypress; MisU	S	P	2,840	10	ML		
248	0	4	0	*x*	*x*		37.8	0.12	Aux Vases; MisU	S	P	3,120	15	AL		
249				*x*	*x*		*x*	*x*	McClosky; MisL[25]	L	P	3,226	9	ML		
250	0	0	0						26							
251	0	236	0	*x*	*x*		41.7	0.12	Tar Springs; MisU	S	P	2,100	34	A	MisL	3,205
252	0	15	0												MisL	2,963
253	0	1	0	*x*	*x*		*x*	*x*	Cypress; MisU	S	P	2,440	10	A		
254	0	4	0	*x*	*x*		*x*	*x*	Paint Creek, MisU	S	P	2,595	10	A		
255	0	2	0	*x*	*x*		38.4	0.15	Bethel; MisU	S	P	2,605	10	A		
256	0	2	0	*x*	*x*		39.0	0.15	Aux Vases; MisU	S	P	2,696	10	AL		
257	0	4	0	*x*	*x*		37.4	0.17	Levias; MisL	L	P	2,720	8	AC		
258	0	0	0	*x*	*x*		38.4	0.15	Rosiclare; MisL	S	P	2,780	7	AL		
259	0	0	0	*x*	*x*		*x*	*x*	McClosky; MisL	L	P	2,785	5	AC		
260	0	2	0						26						MisL	3,460
261	0	1	0	*x*	*x*		38.8	0.15	Levias; MisL	L	P	2,894	11	*x*	MisL	2,980
262	0	1	0	*x*	*x*		*x*	*x*	McClosky; MisL	L	P	2,975	6	*x*	Dev	4,688
263	0	5	0													
264	0	4	0	0	0		39.2	0.17	Aux Vases; MisU	S	P	2,700	7	*x*		
265				*x*	*x*		*x*	*x*	Rosiclare; MisL	S	P	2,836	16	*x*		
266				*x*	*x*		*x*	*x*	McClosky; MisL	L	P	2,856	7	*x*		
267	0	1	0						26						MisL	3,455
268	0	2	0	*x*	*x*		37.8	0.16	McClosky; MisL	L	P	3,120	12	A	MisL	3,298
269	0	1	0	*x*	*x*		*x*	*x*	Aux Vases; MisU	S	P	3,122	11	AL	MisL	2,725
270	0	1	0	*x*	*x*		*x*	*x*	McClosky; MisL	L	P	2,715	8	ML	MisL	2,995
271	0	15	0													
272	0	14	0	*x*	*x*		38.4	0.13	Tar Springs; MisU	S	P	2,050	15	A		
273	0	1	0	*x*	*x*		*x*	*x*	Aux Vases; MisU	S	P	2,700	15	AL	MisL	3,156
274	0	8	0													
275	0	6	0	*x*	*x*		*x*	*x*	Tar Springs; MisU	S	P	2,040	15	A		
276	0	2	0	*x*	*x*		37.2	0.23	Levias; MisL	L	P	2,765	8	AC	MisL	3,130
277	0	3	0													
278	0	1	0	*x*	*x*		*x*	*x*	Cypress; MisU	S	P	2,540	10	A		
279				*x*	*x*		*x*	*x*	McClosky; MisL[25]	L	P	2,870	5	AC		
280	0	1	0	*x*	*x*		*x*	*x*	St. Louis; MisL	L	P	3,060	7	AC		
281	0	1	0						26						MisL	2,942
282	0	3	0													
283	0	2	0	*x*	*x*		*x*	*x*	Aux Vases; MisU	S	P	2,680	32	AL		
284	0	1	0	*x*	*x*		*x*	*x*	Levias; MisL	L	P	2,752	20	AC	MisL	3,010
285	0	4	0													
286	0	2	0	*x*	*x*		36.0	*x*	Palestine; MisU	S	P	1,830	10	AL		
287	0	0	0	*x*	*x*		*x*	*x*	Waltersburg; MisU	S	P	1,990	10	AL		
288	0	1	0	*x*	*x*		*x*	*x*	Aux Vases; MisU	S	P	2,695	12	AL		
289	0	0	0	*x*	*x*		*x*	*x*	McClosky; MisU	L	P	2,730	10	AC	MisL	3,020
290	0	97	0													
291	0	3	0	*x*	*x*		24.4	0.31	Pennsylvanian; Pen	S	P	780	10	Af		
292				*x*	*x*		*x*	*x*	Degonia; MisU[25]	S	P	1,690	10	Af		
293	0	0	0	*x*	*x*		*x*	*x*	Clore; MisU[25]	S	P	1,725	10	Af		

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e]: To End of 1944	Gas Production: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
294			*x*	*x*	*x*		0	0			
295			*x*	*x*	*x*		0	0	15	9	0
296			*x*	*x*	*x*		0	0	45	1	0
297			*x*	*x*	*x*		0	0	0	0	0
298			*x*	*x*	*x*		0	0	15	5	0
299			*x*	*x*	*x*		0	0	4	0	0
300									14	1	0
301	Inman North, *Gallatin*	1941	50	9,000	0		0	0	3	0	0
302			*x*	*x*	0		0	0	1	0	0
303			*x*	*x*	0		0	0	2	0	0
304	Inman West, *Gallatin*	1942	275	311,000	105,000		0	0	20	0	2
305			*x*	*x*	*x*		0	0	1	0	0
306			*x*	*x*	*x*		0	0	13	0	2
307			*x*	*x*	*x*		0	0			
308									6	0	0
309	Junction, *Gallatin*	1939	150	211,000	18,000		0	0	14	0	0
310	New Haven West, *Gallatin*	1944	160	55,000	55,000		0	0	8	8	0
311	Omaha, *Gallatin*	1940	260	963,000	153,000		*x*	*x*	21	0	0
312			*x*	*x*	*x*		0	0	17	0	0
313			*x*	*x*	*x*		*x*	*x*	4	0	0
314									0	0	0
315	Belle Prairie, *Hamilton*	1940	160	125,000	39,000		0	0	5	3	0
316	Blairsville, *Hamilton*	1942	660	1,034,000	376,000		0	0	29	5	0
317									22	4	0
318									1	0	0
319									4	1	0
320									2	0	0
321	Bungay, *Hamilton*	1941	600	747,000	641,000		0	0	33	20	1
322			*x*	*x*	*x*		0	0	32	19	1
323			*x*	*x*	*x*		0	0	1	1	0
324	Dahlgren, *Hamilton*	1941	540	898,000	35,000		0	0	42	0	2
325	Dale-Hoodville Consolidated, *Hamilton*	1940	5,000	19,240,000	3,132,000		0	0	423	21	8
326			*x*	*x*	*x*		0	0	25	4	0
327			*x*	*x*	*x*		0	0	40	3	0
328			*x*	*x*	*x*		0	0	2	2	2
329			*x*	*x*	*x*		0	0	90	3	1
330			*x*	*x*	*x*		0	0	192	7	5
331			*x*	*x*	*x*		0	0	2	0	0
332			*x*	*x*	*x*		0	0			
333			*x*	*x*	*x*		0	0	25	1	0
334									47	1	0
335	Hoodville East, *Hamilton*	1944[32]	20	600	600		0	0	1	1	1
336	Rural Hill, *Hamilton*	1941	2,840	7,961,000	909,000		0	0	202	7	1
337			*x*	*x*	*x*		0	0	1	0	0
338			*x*	*x*	*x*		0	0			
339			*x*	*x*	*x*		0	0	99	5	0
340			*x*	*x*	*x*		0	0	12	0	0
341			*x*	*x*	*x*		0	0	2	0	0
342			*x*	*x*	*x*		0	0	27	2	1
343									61	0	0
344	Thackeray, *Hamilton*	1944	30	6,000	6,000		0	0	3	3	0
345	Walpole, *Hamilton*	1941	1,420	2,528,000	717,000		0	0	64	6	0
346			*x*	*x*	*x*		0	0	2	0	0
347			*x*	*x*	*x*		0	0	62	6	0
348	West End, *Hamilton*	1944	10	8,000	8,000		0	0	1	1	0
349	Elkville, *Jackson*	1941	10	2,000	500		0	0	1	0	0
350	Bogota, *Jasper*	1943	200	204,000	150,000		0	0	7	1	0
351	Bogota South, *Jasper*	1944	20	4,000	4,000		0	0	1	1	0
352	Boos North, *Jasper*	1940	1,075	2,472,000	227,000		0	0	63	0	1
353			*x*	*x*	*x*		0	0			
354			*x*	*x*	*x*		0	0	63	0	1
355									0	0	0
356	Hidalgo, *Jasper*	1940[33]	20	10,000	0		0	0	1	0	0

[32] Abandoned 1944.
[33] Abandoned 1943.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[48]: Flowing	Wells Producing[g] Dec. 1944: Oil[48]: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Reservoir Pressure, Lb. per Sq. In.[5]: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.[6]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
294				x	x		x	x	Palestine; MisU[25]	S	P	1,840	13	Af		
295	0	18	0	x	x		x	x	Waltersburg; MisU	S	P	1,980	18	ALf		
296	0	41	0	x	x		34.6	0.24	Tar Springs; MisU	S	P	2,080	15	AF		
297	0	2	0	x	x		x	x	Hardinsburg; MisU	S	P	2,135	8	ALf		
298	0	13	0	x	x		35.2	0.23	Cypress; MisU	S	P	2,390	12	ALf		
299	0	4	0	x	x		x	x	McClosky; MisL	L	P	2,800	10	ACf		
300	0	16	0						[26]							
301	0	0	0												MisL	3,020
302	0	0	0	x	x		x	x	Aux Vases; MisU	S	P	2,815	20	ML		
303	0	0	0	x	x		36.6	0.19	McClosky; MisL	L	P	2,860	15	MC		
304	0	18	0												MisL	2,990
305	0	1	0	x	x		x	x	Tar Springs; MisU	S	P	2,175	20	AL		
306	0	11	0	x	x		38.0	x	Cypress; MisU	S	P	2,48?	15	AL		
307				x	x		x	x	McClosky; MisL[25]	L	P	2,875	8	A		
308	0	6	0						[26]							
309	0	14	0	x	x		37.2	0.22	Waltersburg; MisU	S	P	1,765	15	AF	MisL	2,710
310	0	8	0	x	x		x	x	Tar Springs; MisU	S	P	2,100	20	Af	MisL	2,930
311	0	18	x												MisL	2,547
312	0	12	0	x	x		25.9	0.23	Palestine; MisU	S	P	1,690	20	D		
313	0	3	x	x	x		27.0	0.24	Tar Springs; MisU	S	P	1,880	15	D		
314	0	3	0						[26]							
315	0	5	0	x	x		37.0	0.12	McClosky; MisL	L	P	3,445	7	x	MisL	3,580
316	0	28	0												MisL	3,530
317	0	18	0	x	x		38.1	x	Aux Vases; MisU	S	P	3,280	20	AL		
318	0	1	0	x	x		x	x	Levias; MisL	L	P	3,340	7	AC		
319	0	7	0	x	x		38.6	0.13	McClosky; MisL	L	P	3,430	7	AC		
320	0	2	0						[26]							
321	0	32	0												MisL	3,541
322	0	31	0	x	x		36.8	0.24	Aux Vases; MisU	S	P	3,285	15	AL		
323	0	1	0	x	x		x	x	McClosky; MisL	L	P	3,430	8	AC		
324	0	23	0	x	x		38.7	0.18	McClosky; MisL	L	P	3,315	10	A	MisL	3,497
325	0	402	0	x	x	G									Dev	5,354
326	0	23	0	x	x		x	x	Tar Springs; MisU	S	P	2,430	25	AL		
327	0	40	0	x	x		37.6	0.25	Cypress; MisU	S	P	2,680	18	A		
328	0	8	0	x	x		x	x	Paint Creek; MisU	S	P	2,865	x	A		
329	0	60	0	x	x		39.0	0.19	Bethel; MisU	S	P	2,950	20	A		
330	0	146	0	x	x		38.0	0.15	Aux Vases; MisU	S	P	3,020	20	A		
331	0	2	0	x	x		x	x	Levias; MisL	L	P	3,050	6	AC		
332				x	x		38.6	x	Rosiclare; MisL[25]	SL	P	3,060	15	AC		
333	0	24	0	x	x		38.6	0.19	McClosky; MisL	L	P	3,075	5	AC		
334	0	99	0						[26]							
335	0	0	0	x	x		x	x	McClosky; MisL	L	P	3,364	9	x	MisL	3,387
336	0	185	0			G									MisL	3,450
337	0	1	0	x	x		x	x	Cypress; MisU	S	P	2,705	22	A		
338				x	x		x	x	Paint Creek; MisU[25]	S	P	3,040	20	A		
339	0	73	0	x	x		38.0	0.15	Aux Vases; MisU	S	P	3,130	25	A		
340	0	12	0	x	x		x	x	Levias; MisL	L	P	3,175	15	AC		
341	0	2	0	x	x		38.6	x	Rosiclare; MisL	SL	P	3,200	5	AC		
342	0	26	0	x	x		38.6	0.19	McClosky; MisL	L	P	3,230	10	AC		
343	0	71	0						[26]							
344	0	3	0	x	x		x	x	Aux Vases; MisU	S	P	3,390	15	ML	MisU	3,410
345	0	64	0			G									MisL	3,331
346	0	2	0	x	x		36.1	x	Tar Springs; MisU	S	P	2,465	6	AL		
347	0	62	0	x	x		38.4	0.13	Aux Vases; MisU	S	P	3,070	25	A	MisL	3,419
348	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	3,130	14	ML	MisL	2,387
349	0	1	0	x	x		35.8	0.22	Bethel; MisU	S	P	2,000	10	x	MisL	3,234
350	0	7	0	x	x		x	x	McClosky; MisL	L	P	3,110	10	A	MisL	3,185
351	0	1	0	x	x		x	x	McClosky; MisL	L	P	3,054	4	ML	MisL	2,950
352	0	56	0													
353				x	x		x	x	Rosiclare; MisL[25]	S	P	2,765	x	AC		
354	0	50	0	x	x		38.6	0.20	McClosky; MisL	L	P	2,800	9	A		
355	0	6	0						[26]							
356	0	0	0	x	x		38.6	0.20	McClosky; MisL	L	P	2,598	8	MC	Dev	4,140

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e]: To End of 1944	Gas Production: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
357	Newton, *Jasper*	1944	20	300	300		0	0	1	1	0
358	Ste. Marie, *Jasper*	1941	430	477,000	50,000		0	0	20	0	0
359	Willow Hill, *Jasper*	1944	20	2,000	2,000		0	0	1	1	0
360	Belle Rive, *Jefferson*	1943	100	118,000	48,000		0	0	5	0	0
361	Boyd, *Jefferson*	1944	180	157,000	157,000		0	0	15	15	0
362			*x*	*x*	*x*		0	0	9	9	0
363			*x*	*x*	*x*		0	0	1	1	0
364									5	5	0
365	Coil West, *Jefferson*	1942	300	129,000	94,000		0	0	10	6	0
366			*x*	*x*	*x*		0	0	1	1	0
367			*x*	*x*	*x*		0	0	0	0	0
368			*x*	*x*	*x*		0	0			
369			*x*	*x*	*x*		0	0	2	2	0
370									7	3	0
371	Cravat, *Jefferson*	1939	100	219,000	24,000		0	0	11	0	0
372	Divide, *Jefferson*	1943	320	180,000	155,000		0	0	11	8	0
373	Divide West, *Jefferson*	1944	240	67,000	67,000		0	0	11	11	0
374			*x*	*x*	*x*		0	0			
375			*x*	*x*	*x*		0	0	10	10	0
376									1	1	0
377	Elk Prairie, *Jefferson*	1938[34]	10	700	0		0	0	1	0	0
378	Fitzgerrell, *Jefferson*	1944	10	1,000	1,000		0	0	1	1	0
379	Ina, *Jefferson*	1938	20	16,000	500		0	0	2	0	0
380	King, *Jefferson*	1942	660	481,000	192,000		0	0	29	6	0
381			*x*	*x*	*x*		0	0	21	5	0
382			*x*	*x*	*x*		0	0			
383			*x*	*x*	*x*		0	0	2	1	0
384			*x*	*x*	*x*		0	0			
385									6	0	0
386	Marcoe, *Jefferson*	1938[35]	20	12,500	0		0	0	2	0	0
387	Markham City, *Jefferson*	1942	600	738,000	162,000		0	0	19	2	2
388			*x*	*x*	*x*		0	0	0	0	0
389			*x*	*x*	*x*		0	0	19	2	2
390	Mt. Vernon, *Jefferson*	1943	160	69,000	49,000		0	0	7	2	0
391			*x*	*x*	*x*		0	0	3	0	0
392			*x*	*x*	*x*		0	0			
393			*x*	*x*	*x*		0	0	3	2	0
394									1	0	0
395	Nason, *Jefferson*	1943	20	4,000	4,000		0	0	1	0	0
396	Roaches, *Jefferson*	1938	160	453,000	25,000		0	0	11	0	1
397			*x*	*x*	*x*		0	0	0	0	0
398			*x*	*x*	*x*		0	0			
399									11	0	1
400	Roaches North, *Jefferson*	1944	300	149,000	149,000		0	0	29	29	0
401			*x*	*x*	*x*		0	0	27	2	0
402			*x*	*x*	*x*		0	0	2	2	0
403									0	0	0
404	Waltonville, *Jefferson*	1943	60	14,000	9,000		0	0	4	3	0
405	Woodlawn, *Jefferson*	1940	1,320	7,897,000	837,000		0	0	162	0	3
406			*x*	*x*			0	0	1	0	0
407			*x*	*x*	*x*		0	0	161	0	3
408									0	0	0
409	Dix, *Jefferson, Marion*	1938	1,510	4,050,000	509,000		0	0	84	0	0
410			*x*	*x*	*x*		0	0	83	0	0
411			*x*	*x*	*x*		0	0	1	0	0
412	Kell, *Jefferson*	1942[36]	10	3,000	0		0	0	1	0	0
413	Markham City North, *Jefferson, Wayne*	1943	480	470,000	394,000		0	0	15	8	1
414			*x*	*x*	*x*		0	0	2	2	0
415			*x*	*x*	*x*		0	0	13	6	1
416	Beman, *Lawrence*	1942	20	3,000	1,000		0	0	1	0	0
417	Ruark, *Lawrence*	1941	20	3,000	1,000		0	0	2	1	0

[34] Abandoned 1940.
[35] Abandoned 1941.
[36] Abandoned 1944.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43] Flowing	Wells Producing[g] Dec. 1944: Oil[43] Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[6]: Initial	Reservoir Pressure, Lb. per Sq. In.[6]: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F[6]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
357	0	1	0	x	x		x	x	McClosky; MisL	L	P	2,930	5	MC	MisL	3,022
358	0	16	0	x	x		40.2	0.14	McClosky; MisL	L	P	2,830	8	A	MisL	2,935
359	0	1	0	x	x		x	x	McClosky; MisL	L	P	2,665	5	MC	MisL	2,742
360	0	5	0	x	x		39.4	0.15	McClosky; MisL	L	P	3,085	7	AC	MisL	3,240
361	0	15	0												MisL	2,333
362	0	8	0	550±	x		x	x	Bethel; MisU	S	P	2,050	15	A		
363	0	1	0	615±	x		x	x	Aux Vases; MisU	S	P	2,130	20	A		
364	0	6	0						26							
365	0	9	0												MisL	3,022
366	0	2	0	x	x		x	x	Aux Vases; MisU	S	P	2,729	14	AL		
367	0	1	0	x	x		x	x	Levias; MisL	L	P	2,830	6	AC		
368				x	x		x	x	Rosiclare; MisL[25]	SL	P	2,870	6	AC		
369	0	2	0	x	x		x	x	McClosky; MisL	L	P	2,885	11	AC		
370	0	4	0						26							
371	0	10	0	x	x		35.4	0.23	Bethel; MisU	S	P	2,070	10	A	MisL	2,335
372	0	11	0	x	x		x	x	McClosky; MisL	L	P	2,725	10	AC	MisL	2,921
373	0	11	0												MisL	2,865
374				x	x		x	x	Levias; MisL[25]	L	P	2,690	7	AC		
375	0	10	0	x	x		x	x	McClosky; MisL	L	P	2,740	14	AC		
376	0	1	0						26							
377	0	0	0	x	x		x	x	McClosky; MisL	L	P	2,730	7	x	MisL	3,000
378	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,760	14	x	MisL	3,012
379	0	1	0	x	x		36.4	0.20	St. Louis, MisL	L	P	3,000	5	AC	MisL	3,065
380	0	25	0												Dev	4,760
381	0	22	0	x	x		38.6	0.17	Aux Vases; MisU	S	P	2,730	20	AL		
382				x	x		x	x	Levias; MisL[25]	L	P	2,770	10	AC		
383	0	1	0	x	x		39.6	0.16	Rosiclare; MisL	SL	P	2,815	10	AC		
384				x	x		x	x	McClosky; MisL[25]	L	P	2,840	7	AC		
385	0	2	0						26							
386	0	0	0	x	x		23.2	0.54	McClosky; MisL	L	S	2,745	11	x	MisL	3,066
387	0	16	0												MisL	3,215
388	0	1	0	x	x		x	x	Levias; MisL	L	P	3,060	5	A		
389	0	15	0	x	x		38.2	0.08	McClosky; MisL	L	P	3,090	11	A		
390	0	6	0												MisL	3,008
391	0	2	0	x	x		x	x	Aux Vases; MisU	S	P	2,680	10	AL		
392				x	x		x	x	Levias; MisL[25]	L	P	2,755	5	AC		
393	0	3	0	x	x		x	x	McClosky; MisL	L	P	2,800	6	AC		
394	0	1	0						26							
395	0	1	0	x	x		x	x	Rosiclare; MisL	S	P	2,790	7	MC	MisL	2,805
396	0	8	0												Dev	3,840
397	0	5	0	x	x		37.0	0.22	Rosiclare; MisL	S	P	2,190	12	AC		
398				x	x		x	x	McClosky; MisL[25]	L	P	2,210	7	AC		
399	0	3	0						26							
400	0	29	0												MisL	2,255
401	0	27	0	x	x		x	x	Bethel; MisU	S	P	1,925	12	A		
402	0	1	0	x	x		x	x	Rosiclare; MisL	S	P	2,120	12	AC		
403	0	1	0						26							
404	0	3	0	x	x		37.8	0.14	Bethel, MisU	S	P	2,465	12	A	MisL	2,769
405	0	141	0												MisL	2,365
406	0	3	0	x	x		x	x	Cypress; MisU	S	P	1,800	10	AL		
407	0	136	0	x	x		37.8	0.16	Bethel; MisU	S	P	1,960	25	A		
408	0	1	0						26							
409	0	83	0			P									Dev	3,874
410	0	82	0	x	27.5		39.0	0.23	Bethel; MisU	S	P	1,950	13	A		
411	0	1	0	x	x		x	x	Rosiclare; MisL	S	P	2,100	8	A		
412	0	0	0	x	x		36.2	0.26	McClosky; MisL	L	P	2,625	6	A	MisL	2,720
413	0	14	0												MisL	3,166
414	0	2	0	x	x		x	x	Aux Vases; MisU	S	P	2,950	10	AL		
415	0	12	0	x	x		x	x	McClosky; MisL	L	P	3,100	10	AC		
416	0	1	0	x	x		x	x	McClosky; MisL	L	P	1,841	2	MC	MisL	1,845
417	0	2	0	x	x		32.0	x	Buchanan; Pen	S	P	1,510	14	ML	MisL	2,320

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
418	Russellville gas, *Lawrence*	1937	1,800	0	0		6,126	600	62	3	1
419							*x*	*x*	18	2	1
420							*x*	*x*	44	1	0
421	St. Francisville East, *Lawrence*	1941	90	104,000	24,000		0	0	9	0	0
422	Sumner, *Lawrence*	1944	20	2,000	2,000		0	0	1	1	0
423	Carlinville North, *Macoupin*	1941	40	600	100		0	0	4	1	0
424	Plainview, *Macoupin*	1942	10	800	0		0	0	1	0	0
425	Marine, *Madison*	1943	960	497,000	479,000		0	0	28	24	0
426	St. Jacob, *Madison*	1942	1,320	1,098,000	413,000		0	0	47	14	0
427	Alma, *Marion*	1941	60	47,000	8,000		0	0	5	1	1
428				*x*	*x*		0	0	3	1	1
429				*x*	*x*		0	0	2	0	0
430	Exchange, *Marion*	1943	80	19,000	12,000		0	0	2	0	0
431	Patoka, *Marion*	1937	960	3,768,000	630,000		0	0	149	16	0
432			*x*	*x*	*x*		0	0	144	15	0
433			*x*	*x*	*x*		0	0	4	1	0
434			*x*	*x*	*x*		0	0	1	0	0
435	Patoka East, *Marion*	1941	430	2,174,000	361,000		0	0	59	0	0
436			*x*	*x*	*x*		0	0	54	0	0
437			*x*	*x*	*x*		0	0	5	0	0
438	Salem, *Marion*	1938	9,600	185,438,000	8,197,000		0	0	2,454	10	12
439			*x*	*x*	*x*		0	0	485	4	*x*
440			*x*	*x*	*x*		0	0	152	0	*x*
441			*x*	*x*	*x*		0	0	9	4	*x*
442			*x*	*x*	*x*		0	0	551	0	*x*
443			*x*	*x*	*x*		0	0	8	0	*x*
444			*x*	33,812,000	740,000		0	0	541	0	*x*
445			*x*	2,424,000	375,000		0	0	2	2	*x*
446									706	0	*x*
447	Tonti, *Marion*	1939	480	6,876,000	597,000		0	0	59	1	0
448			*x*	*x*	*x*		0	0	5	0	0
449			*x*	*x*	*x*		0	0	15	0	0
450			*x*	*x*	*x*		0	0	31	0	0
451			*x*	1,500,000	40,000		0	0	6	0	0
452									2	1	0
453	Fairman, *Marion, Clinton*	1939	490	1,020,000	115,000		0	0	25	0	2
454	Mt. Olive, *Montgomery*	1942	30	1,000	0		0	0	3	1	0
455	Raymond, *Montgomery*	1940	80	4,000	1,000		0	0	6	2	0
456	Waggoner, *Montgomery*	1940	40	6,000	1,000		0	0	4	0	0
457	Tamaroa, *Perry*	1942	50	6,000	3,000		0	0	3	0	0
458	Amity, *Richland*	1942	20	5,000	2,000		0	0	1	0	0
459	Bonpas, *Richland*	1941	40	76,000	13,000		0	0	2	0	0
460	Calhoun, *Richland*	1944	120	71,000	71,000		0	0	6	6	0
461			*x*	*x*	*x*		0	0	4	4	0
462			*x*	*x*	*x*		0	0	2	2	0
463	Calhoun North, *Richland*	1944	20	2,000	2,000		0	0	1	1	0
464			*x*	*x*	*x*		0	0			
465			*x*	*x*	*x*		0	0			
466									1	1	0
467	Olney, *Richland*	1937	720	1,498,000	129,000		0	0	45	3	0
468			*x*	*x*	*x*		0	0	1	0	0
469			*x*	*x*	*x*		0	0	44	3	0
470	Olney East, *Richland*	1944	20	8,000	8,000		0	0	1	1	0
471	Schnell, *Richland*	1938	160	193,000	1,000		0	0	4	0	0
472	Stringtown, *Richland*	1941	140	184,000	25,000		0	0	8	0	0
473	Noble, *Richland, Clay*	1937	6,700	20,781,000	3,593,000		*x*	*x*	376	62	3
474			*x*	*x*	*x*		0	0	136	7	0
475			*x*	*x*	*x*		0	0	0	0	0
476			*x*	*x*	*x*		0	0	240	55	3
477									0	0	0
478	Parkersburg Consolidated, *Richland, Edwards*	1941	970	3,330,000	447,000		0	0	48	0	0
479			*x*	*x*	*x*		0	0	1	0	0
480			*x*	*x*	*x*		0	0	1	0	0
481			*x*	*x*	*x*		0	0	1	0	0

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[48]: Flowing	Wells Producing[g] Dec. 1944: Oil[48]: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Reservoir Pressure, Lb. per Sq. In.[5]: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F[8]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
418	0	0	60												Dev	3,133
419	0	0	17	x	x				Bridgeport; Pen	S	P	760	15	A		
420	0	0	43	x	x				Buchanan; Pen	S	P	1,100	12	A		
421	0	8	0	x	x		39.8	0.21	Bethel; MisU	S	P	1,760	22	A	MisL	1,960
422	0	1	0	x	x		x	x	McClosky; MisL	L	P	2,261	4	MC	MisL	2,365
423	0	3	0	x	x		20.3	0.35	Pottsville; Pen	S	P	450	10	x	Pen	562
424	0	0	0	x	x		x	x	Pennsylvanian; Pen	S	P	400	20	x	Pen	421
425	0	28	0	600	x		x	x	Silurian; Sil	L	P	1,740	5	R[41]	Ord	2,590
426	0	44	0	x	x		40.0	0.23	"Trenton"; Ord	L	P	2,260	17	A	Ord	2,549
427	0	2	0												Dev	3,692
428	0	1	0	x	x		x	x	Bethel; MisU	S	P	1,931	8	A		
429	0	1	0	x	x		x	x	Rosiclare; MisL	S	P	2,084	10	A		
430	0	2	0	x	x		x	x	McClosky; MisL	L	P	2,735	8	MC	MisL	2,869
431	0	83	0			W									Dev	3,142
432	0	79	0	x	10		39.5	0.16	Bethel; MisU	S	P	1,410	25	D		
433	0	3	0	x	650		40.9	0.31	Rosiclare; MisL	S	P	1,560	15	D		
434	0	1	0	x	1,200		40.0	0.28	Devonian; Dev	L	P	2,835	8	D		
435	0	54	0												MisL	1,740
436	0	47	0	x	x		36.1	0.23	Cypress; MisU	S	P	1,340	19	A		
437	0	7	0	x	x		36.1	0.23	Bethel; MisU	S	P	1,465	10	A		
438	0	2,200	0			G									Prairie du Chien	5,655
439	0	381	0	x	x		38.5	0.20	Bethel; MisU	S	P	1,780	40	A		
440	0	82	0	x	x		38.6	0.21	Aux Vases; MisU	S	P	1,825	40	A		
441	0	11	0	x	x		39.0	x	Rosiclare; MisL	S	P	1,950	5	AL		
442	0	348	0	x	x		39.0	x	McClosky; MisL	OL	P	1,990	17	A		
443	0	8	0	x	x		39.0	x	Salem; MisL	L	P	2,160	17	A		
444	0	354	0	x	x		42.1	0.28	Devonian; Dev	L	Cav	3,430	50	A		
445	0	65	0	x	x		42.0	x	"Trenton"; Ord	L	Cav	4,500	50			
446	0	951	0						[26]						Dev	3,742
447	0	58	0													
448	0	5	0	x	x		39.0	x	Bethel; MisU	S	P	1,930	20	D		
449	0	15	0	x	x		39.0	x	Aux Vases; MisU	S	P	2,005	30	D		
450	0	30	0	x	x		39.4	0.21	McClosky; MisL	OL	P	2,130	15	D		
451	0	6	0	x	x		41.0	x	Devonian; Dev	L	Cav	3,500	7	D		
452	0	2	0						[26]							
453	0	17	0	x	x		38.2	0.21	Bethel; MisU	S	P	1,440	8	A	"Trenton"	4,100
454	0	0	0	x	x		33.2	0.16	Pottsville; Pen	S	P	600	4	A	Pen	743
455	0	5	0	x	x		34.8	0.22	Pottsville; Pen	S	P	580	15	ML	MisL	1,001
456	0	1	0	x	x		28.0	0.21	Pottsville; Pen	S	P	610	14	x	Dev	1,893
457	0	2	0	x	x		x	x	Cypress; MisU	S	P	1,125	10	AL	MisL	1,630
458	0	1	0	x	x		x	x	McClosky; MisL	OL	P	2,960	10	MC	MisL	3,090
459	0	2	0	x	x		37.8	0.23	McClosky; MisL	OL	P	3,120	4	MC	MisL	3,212
460	0	6	0												MisL	3,280
461	0	6	0	x	x		x	x	Levias; MisL	OL	P	3,140	9	A		
462	0	0	0	x	x		x	x	McClosky; MisL	OL	P	3,180	5	A		
463	0	1	0											x	MisL	3,280
464				x	x		x	x	Rosiclare; MisL[25]	S	P	3,165	10			
465				x	x		x	x	McClosky; MisL[25]	OL	P	3,184	11			
466	0	1	0						[26]						MisL	3,289
467	0	32	0													
468	0	2	0	x	x		x	x	Levias; MisL	OL	P	3,060	8	A		
469	0	30	0	x	x		37.2	0.19	McClosky; MisL	OL	P	3,050	10	A		
470	0	1	0	x	x		x	x	McClosky; MisL	OL	P	3,080	9	x	MisL	3,094
471	0	4	0	x	x		37.0	0.19	McClosky; MisL	OL	P	3,000	6	AC	MisL	3,150
472	0	7	0	x	x		39.8	0.24	McClosky; MisL	OL	P	3,040	8	AC	MisL	3,080
473	0	331	2			W									MisL	3,200
474	0	130	0	x	x		38.0	0.27	Cypress; MisU	S	P	2,550	25	A		
475	0	1	0	x	x		x	x	Levias; MisL	OL	P	2,957	2	AC		
476	0	195	2	x	x		39.0	0.17	McClosky; MisL	OL	P	2,960	6	AM		
477	0	5	0						[26]						MisL	3,276
478	0	44	0													
479	0	2	0	x	x		x	x	Cypress; MisU	S	P	2,830	12	A		
480	0	0	0	x	x		x	x	Bethel; MisU	S	P	2,930	10	A		
481	0	0	0	x	x		x	x	Levias; MisL	OL	P	3,070	10	AC		

[41] Reef structure.

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
482			x	x	x		0	0	45	0	0
483									0	0	0
484	Parkersburg West, *Richland, Edwards*	1943	90	36,000	24,000		0	0	3	1	0
485	Dundas Consolidated, *Richland, Jasper*	1939	6,580	11,061,000	655,000		0	0	281	0	12
486			x	x	x		0	0	5	0	0
487			x	x	x		0	0	2	0	0
488			x	x	x		0	0	0	0	0
489			x	x	x		0	0	269	0	9
490									5	0	3
491	Dundas East, *Richland, Jasper*	1942	360	571,000	141,000		0	0	16	2	0
492			x	x	x		0	0	0	0	0
493			x	x	x		0	0	17	2	0
494	Eldorado, *Saline*	1941	40	7,000	2,000		0	0	2	0	0
495	Lakewood, *Shelby*	1941	20	30,000	7,000		0	0	2	0	0
496			x	x	x		0	0	1	0	0
497			x	x	x		0	0	1	0	0
498	Stewardson, *Shelby*	1939	70	50,000	10,000		0	0	5	0	0
499	Friendsville, *Wabash*	1942	340	346,000	202,000		0	0	36	7	2
500			x	x	x		0	0	11	2	0
501			x	x	x		0	0	1	1	0
502			x	x	x		0	0	9	0	0
503			x	x	x		0	0	0	0	0
504			x	x	x		0	0	2	0	1
505			x	x	x		0	0	5	0	0
506			x	x	x		0	0	0	0	0
507			x	x	x		0	0	1	0	1
508									7	5	0
509	Keensburg Consolidated, *Wabash*	1939	3,000	9,776,000	868,000		0	0	341	5	3
510			x	x	x		0	0	19	0	0
511			x	x	x		0	0	2	0	0
512			x	x	x		0	0	4	0	0
513			x	x	x		0	0	9	0	0
514			x	x	x		0	0	2[illegible]1	1	1
515			x	x	x		0	0	2	1	0
516			x	x	x		0	0	9	1	0
517			x	x	x		0	0	5	1	0
518			x	x	x		0	0	24	0	2
519									16	1	0
520	Keensburg East, *Wabash*	1939[37]	20	x	x		0	0	3	0	0
521	Keensburg South, *Wabash*	1944	30	15,000	15,000		0	0	2	2	0
522			10	4,000	4,000		0	0	1	1	0
523			20	11,000	11,000		0	0	1	1	0
524	Lancaster East, *Wabash*	1944	10	x	x		0	0	1	1	0
525	Maud, *Wabash*	1940	250	366,000	[illegible]0,000		0	0	20	0	2
526			x	x	x		0	0	2	0	0
527			x	x	x		0	0	1	0	0
528			x	x	x		0	0	1	0	0
529			x	x	x		0	0	1	0	2
530			x	x	x		0	0	15	0	0
531									1	0	0
532	Mt. Carmel, *Wabash*	1940	3,600	4,940,000	1,330,000		x	x	333	47	8
533			x	x	x		0	0	46	6	2
534			x	x	x		0	0			
535			x	x	x		0	0	1	0	0
536			x	x	x		0	0	4	3	0
537			x	x	x		x	x	207	25	5
538			x	x	x		0	0	2	0	0
539			x	x	x		0	0	1	1	0
540			x	x	x		0	0	2	0	0
541			x	x	x		0	0	37	5	1
542									33	7	0
543	Mt. Carmel West, *Wabash*	1939	60	13,000	4,000		0	0	4	0	0
544			x	x	x		0	0	2	0	0
545			x	x	x		0	0	2	0	0

[37] Abandoned 1943.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[48] Flowing	Oil[48] Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.[6]	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
482	0	36	0	x	x		38.0	0.31	McClosky; MisL	OL	P	3,135	9	A		
483	0	6	0						[26]							
484	0	3	0	x	x		x	x	McClosky; MisL	OL	P	3,250	5	AC	MisL	3,331
485	0	267	0			W									Dev	4,585
486	0	5	0	x	x		37.0	x	Cypress; MisU	S	P	2,520	12	AL		
487	0	2	0	x	x		38.0	x	Aux Vases; MisU	S	P	2,795	9	A		
488	0	1	0	x	x		x	x	Rosiclare; MisU	SL	P	2,845	6	AL		
489	0	243	0	x	x		38.4	0.17	McClosky; MisL	OL	P	2,974	7	A		
490	0	16	0						[26]							
491	0	15	0												MisL	3,105
492	0	1	0	x	x		x	x	Levias; MisL	OL	P	x	x	A		
493	0	14	0	x	x		x	x	McClosky; MisL	OL	P	3,000	8	A		
494	0	1	0	x	x		34.2	0.14	Aux Vases; MisU	S	P	3,813	23	A	MisL	3,000
495	0	2	0												MisL	1,875
496	0	1	0	x	x		29.6	x	Bethel; MisU	S	P	1,692	9	x		
497	0	1	0	x	x		31.7	0.23	Aux Vases; MisU	S	P	1,723	9	x		
498	0	5	0	x	x		37.8	0.18	Aux Vases; MisU	S	P	1,940	8	A	MisL	2,798
499	0	32	0												MisL	
500	0	10	0	x	x		31.0	0.22	Biehl; Pen	S	P	1,760	15	A		
501	0	1	0	x	x		27.3	0.25	Palestine; MisU	S	P	1,785	13	A		
502	0	7	0	x	x		35.2	0.17	Cypress; MisU	S	P	2,300	12	A		
503	0	1	0	x	x		x	x	Paint Creek; MisU	S	P	2,465	15	A		
504	0	1	0	x	x		36.7	0.18	Bethel; MisU	S	P	2,470	10	A		
505	0	4	0	x	x		x	x	Levias; MisL	OL	P	2,633	6	AC		
506	0	1	0	x	x		x	x	Rosiclare; MisL	SL	P	x	5	AC		
507	0	0	0	x	x		x	x	McClosky; MisL	OL	P	2,645	5	AC		
508	0	0	0						[26]							
509	0	267	0												MisL	3,065
510	0	17	0	x	x		38.0	x	Biehl; Pen	S	P	1,720	10	AL		
511	0	2	0	x	x		x	x	Clore; MisU	S	P	1,830	10	AL		
512	0	4	0	x	x		x	x	Palestine; MisU	S	P	1,900	13	AL		
513	0	9	0	x	x		x	x	Tar Springs; MisU	S	P	2,100	15	AL		
514	0	172	0	x	x		38.6	0.29	Cypress; MisU	S	P	2,250	18	A		
515	0	2	0	x	x		x	x	Paint Creek; MisU	S	P	2,550	12	AL		
516	0	9	0	x	x		36.6	x	Bethel; MisU	S	P	2,575	18	AL		
517	0	5	0	x	x		x	x	Aux Vases; MisU	S	P	2,760	15	AL		
518	0	21	0	x	x		37.9	0.38	McClosky; MisL	OL	P	2,800	7	AC		
519	0	26	0						[26]							
520	0	0	0	x	x		37.6	0.26	McClosky; MisL	OL	P	2,710	6	MC	MisL	2,741
521	0	2	0												MisL	2,882
522	0	1	0	300±	x		x	x	Pennsylvanian; Pen	S	P	1,140	15	AL		
523	0	1	0	x	x		x	x	McClosky; MisL	OL	P	2,714	10	AC		
524	0	1	0	x	x		x	x	Biehl; Pen	S	P	1,750	10	ML	MisU	2,630
525	0	15	0												MisL	2,793
526	0	2	0	x	x		37.7	x	Waltersburg; MisU	S	P	1,935	17	AL		
527	0	1	0	x	x		x	x	Hardinsburg; MisU	S	P	2,115	22	AL		
528	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,464	8	AL		
529	0	0	0	x	x		38.0	0.30	Rosiclare; MisL	SL	P	2,640	9	AC		
530	0	9	0	x	60±		38.0	0.30	McClosky; MisL	OL	P	2,650	8	A		
531	0	2	0						[26]						MisL	2,475
532	1	285	1			G										
533	0	41	0	x	x		32.0	x	Biehl; Pen	S	P	1,470	25	AL		
534				x	x		x	x	Jordan; Pen[25]	S	P	1,520	15	AL		
535	0	1	0	x	x		x	x	Palestine; MisU	S	P	1,540	10	AL		
536	0	4	0	x	x		x	x	Tar Springs; MisU	S	P	1,790	15	AL		
537	0	166	1	x	x		38.4	x	Cypress; MisU	S	P	2,020	15	ALf		
538	0	2	0	x	x		x	x	Bethel; MisU	S	P	2,110	15	AL		
539	0	1	0	x	x		x	x	Levias; MisL	OL	P	2,320	5	AC		
540	0	2	0	x	x		36.6	0.36	Rosiclare; MisL	S	P	2,350	5	AC		
541	1	34	0	x	x		38.4	0.42	McClosky; MisL	OL	P	2,360	5	AC		
542	0	34	0						[26]						MisL	3,50
543	0	3	0													
544	0	2	0	x	x		x	x	Waltersburg; MisU	S	P	1,878	11	ML		
545	0	1	0	x	x		30.0	0.25	Tar Springs; MisU	S	P	1,930	6	ML		

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
546	Patton, *Wabash*	1940	40	13,000	8,000		0	0	8	0	0
547			*x*	*x*	*x*		0	0	7	0	0
548			*x*	*x*	*x*		0	0	1	0	0
549	Patton West, *Wabash*	1943	400	92,000	75,000		0	0	28	24	0
550			*x*	*x*	*x*		0	0	2	2	0
551			*x*	*x*	*x*		0	0	13	13	0
552			*x*	*x*	*x*		0	0	0	0	0
553			*x*	*x*	*x*		0	0	3	3	0
554			*x*	*x*	*x*		0	0			
555			*x*	*x*	*x*		0	0	2	0	0
556			*x*	*x*	*x*		0	0	6	4	0
557									2	2	0
558	Lancaster, *Wabash, Lawrence*	1940	1,200	936,000	391,000		0	0	70	36	2
559			*x*	*x*	*x*		0	0	4	4	0
560			*x*	*x*	*x*		0	0	35	30	1
561			*x*	*x*	*x*		0	0	1	1	0
562			*x*	*x*	*x*		0	0	29	0	1
563									1	1	0
564	Cordes, *Washington*	1939	1,500	2,888,000	344,000		0	0	141	3	0
565	Dubois, *Washington*	1939	140	120,000	16,000		0	0	10	0	2
566	Dubois West, *Washington*	1942	10	6,000	2,000		0	0	1	0	0
567	Irvington, *Washington*	1940	800	3,291,000	437,000		0	0	86	1	0
568			*x*	*x*	*x*		0	0	2	0	0
569			*x*	*x*	*x*		0	0	76	1	0
570			*x*	*x*	*x*		0	0			
571			*x*	*x*	76,000		0	0	7	0	0
572									1	0	0
573	McKinley, *Washington*	1940	80	180,000	13,000		0	0	7	0	0
574			50	*x*	*x*		0	0	6	0	0
575			*x*	*x*	*x*		0	0	1	0	0
576	Barnhill, *Wayne*	1939	800	1,782,000	97,000		0	0	65	0	7
577			*x*	*x*	*x*		0	0	1	0	1
578			*x*	*x*	*x*		0	0	0	0	0
579			*x*	*x*	*x*		0	0	61	0	6
580			*x*	*x*	*x*		0	0	1	0	0
581									2	0	0
582	Boyleston Consolidated, *Wayne*	1938	4,300	6,571,000	1,015,000		0	0	177	14	5
583			*x*	*x*	*x*		0	0	2	0	0
584			*x*	*x*	*x*		0	0	10	0	0
585			*x*	*x*	*x*		0	0	1	0	0
586			*x*	*x*	*x*		0	0	154	10	4
587									10	4	1
588	Cisne, *Wayne*	1937	940	2,912,000	120,000		0	0	49	1	0
589			*x*	*x*	*x*		0	0	2	0	0
590			*x*	*x*	*x*		0	0	1	0	0
591			*x*	*x*	*x*		0	0	46	1	0
592									0	0	0
593	Cisne North, *Wayne*	1942	20	9,000	2,000		0	0	2	0	0
594	Coil, *Wayne*	1942	440	777,000	186,000		0	0	18	2	0
595			*x*	*x*	*x*		0	0	16	2	0
596			*x*	*x*	*x*		0	0	2	0	0
597	Covington South, *Wayne*	1943	360	86,000	34,000		0	0	8	1	1
598	Fairfield, *Wayne*	1942	40	10,000	4,000		0	0	2	1	1
599	Geff, *Wayne*	1941	500	650,000	237,000		0	0	27	8	0
600			*x*	*x*	*x*		0	0	19	7	0
601			*x*	*x*	*x*		0	0	1	1	0
602			*x*	*x*	*x*		0	0	7	0	0
603	Geff West, *Wayne*	1942	60	47,000	15,000		0	0	3	0	0
604	Goldengate Consolidated, *Wayne*	1939	1,200	846,000	548,000		0	0	36	14	1
605			*x*	*x*	*x*		0	0	5	0	0
606			*x*	*x*	*x*		0	0	2	1	0
607			*x*	*x*	*x*		0	0	2	0	0
608			*x*	*x*	*x*		0	0	14	3	1
609									13	10	0

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43] Flowing	Oil[43] Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.[b]: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.[j]	Sulphur, Per Cent	Producing Formation: Name and Age[f]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
546	0	6	0												MisL	2,315
547	0	5	0	x	x		x	x	Biehl; Pen	S	P	1,470	15	AL		
548	0	1	0	x	x		x	x	McClosky; MisL	OL	P	2,310	4	MC		
549	0	28	0												MisL	2,571
550	0	2	0	x	x		x	x	Biehl; MisU	S	P	1,542	22	AL		
551	0	13	0	x	x		x	x	Cypress; MisU	S	P	2,029	12	AL		
552	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,139	20	AL		
553	0	3	0	x	x		x	x	Aux Vases; MisU	S	P	2,283	4	AL		
554				x	x		x	x	Levias; MisL	OL	P	2,308	4	AC		
555	0	2	0	x	x		x	x	Rosiclare; MisL	SL	P	2,308	4	AC		
556	0	6	0	x	x		x	x	McClosky; MisL	OL	P	2,346	6	AC		
557	0	1	0						[26]						MisL	2,908
558	0	54	0													
559	0	4	0	x	x		39	x	Paint Creek; MisU	S	P	2,320	22	AL		
560	0	34	0	x	x		x	x	Bethel; MisU	S	P	2,530	12	AL		
561	0	1	0	x	x		x	x	Levias; MisL	OL	P	2,672	11	AC		
562	0	14	0	x	x		39.8	0.28	McClosky; MisL	OL	P	2,690	5	A		
563	0	1	0						[26]							
564	0	139	0	x	x		37.4	0.19	Bethel; MisU	S	P	1,260	14	A	MisL	1,560
565	0	8	0	x	x		38.0	0.26	Bethel; MisU	S	P	1,355	8	A	Dev	3,535
566	0	1	0	x	x		x	x	Bethel; MisU	S	P	1,345	6	x	MisL	1,685
567	0	82	0												Dev	3,362
568	0	1	0	x	x		x	x	Cypress; MisU	S	P	1,380	15	A		
569	0	71	0	x	x		37.6	0.16	Bethel; MisU	S	P	1,535	10	A		
570				x	x		x	x	Aux Vases; MisU[25]	S	P	1,605	x	A		
571	0	7	0	x	x		39.0	0.27	Devonian; Dev	L	Cav	3,090	5	A		
572	0	3	0						[26]						Dev	2,565
573	0	4	0													
574	0	4	0	x	x		44.1	0.18	Bethel; MisU	S	P	1,000	7	A		
575	0	0	0	x	x		41.7	x	Devonian; Dev	L	Cav	2,250	10	A	MisL	3,855
576	0	36	0													
577	0	8	0	x	x		x	x	Aux Vases; MisU	S	P	3,225	15	AL		
578	0	1	0	x	x		x	x	Rosiclare; MisL	OL	P	3,350	9	AC		
579	0	27	0	x	x		37.6	0.17	McClosky; MisL	OL	P	3,400	12	A		
580	0	0	0	x	x		x	x	Salem; MisL	L	P	3,795	8	AC		
581	0	0	0						[26]						MisL	3,495
582	0	165	0													
583	0	5	0	x	x		39.6	x	Aux Vases; MisU	S	P	3,095	7	AL		
584	0	10	0	x	x		x	x	Levias; MisL	OL	P	3,180	4	AC		
585	0	1	0	x	x		40.2	0.14	Rosiclare; MisL	OL	P	3,215	6	AC		
586	0	140	0	x	x		40.2	0.14	McClosky; MisL	OL	P	3,240	7	AC		
587	0	9	0						[26]						St. Peter	7,205
588	0	42	0													
589	0	2	0	x	x		38.5	x	Aux Vases; MisU	S	P	3,002	8	AL		
590	0	2	0	x	x		x	x	Rosiclare; MisL	SL	P	3,086	9	AC		
591	0	23	0	x	x		35.8	0.24	McClosky; MisL	OL	P	3,117	11	A		
592	0	15	0						[26]						MisL	3,245
593	0	2	0	x	x		39.0	x	McClosky; MisL	OL	P	3,170	10	ML	MisL	3,185
594	0	16	0													
595	0	14	0	x	x		37.1	0.20	Aux Vases; MisU	S	P	2,900	22	A		
596		2	0	x	x		37.5	x	McClosky; MisL	OL	P	2,970	3	AC	MisL	3,389
597	0	7	0	x	x		39.4	0.18	McClosky; MisL	OL	P	3,310	8	AC	MisL	3,410
598	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	3,235	14	AL	MisL	3,390
599	0	27	0													
600	0	19	0	x	x		40.4	0.13	Aux Vases; MisU	S	P	3,065	14	AL		
601	0	1	0	x	x		x	x	Rosiclare; MisL	OL	P	3,089	4	AC		
602	0	7	0	x	x		34.0	0.33	McClosky; MisL	OL	P	3,135	3	AC	MisL	3,320
603	0	3	0	x	x		x	x	Aux Vases; MisU	S	P	3,130	20	AL	Dev	5,645
604	0	30	0													
605	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	3,180	15	AL		
606	0	0	0	x	x		x	x	Levias; MisL	OL	P	3,252	6	AC		
607	0	0	0	x	x		x	x	Rosiclare; MisL	SL	P	3,275	5	AC		
608	0	16	0	x	x		34.4	0.18	McClosky; MisL	OL	P	3,308	9	AC		
609	0	13	0						[26]							

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
610	Johnsonville, *Wayne*	1941	4,200	14,293,000	1,425,000		0	0	249	2	1
611			*x*	*x*	*x*		0	0	35	2	0
612			*x*	*x*	*x*		0	0	0	0	0
613			*x*	*x*	*x*		0	0	207	0	1
614									7	0	0
615	Johnsonville North, *Wayne*	1943	40	18,000	13,000		0	0	1	0	0
616			*x*	*x*	*x*		0	0			
617			*x*	*x*	*x*		0	0			
618									1	0	0
619	Johnsonville South, *Wayne*	1942	20	13,000	2,000		0	0	2	0	0
620			*x*	*x*	*x*		0	0	1	0	0
621			*x*	*x*	*x*		0	0	1	0	0
622	Johnsonville West, *Wayne*	1942[38]	40	3,000	2,000		0	0	2	0	0
623			*x*	*x*	*x*		0	0	1	0	0
624			*x*	*x*	*x*		0	0	1	0	0
625	Leech Township, *Wayne*	1938	240	439,000	38,000		0	0	14	0	0
626	Mayberry, *Wayne*	1941	330	195,000	34,000		0	0	6	0	0
627	Mt. Erie North, *Wayne*	1944	60	16,000	16,000		0	0	4	4	0
628			*x*	*x*	*x*		0	0	1	1	0
629			*x*	*x*	*x*		0	0	3	3	0
630	Mt. Erie South, *Wayne*	1939[39]	360	119,000	69,000		0	0	10	1	0
631			*x*	*x*	*x*		0	0	4	0	0
632			*x*	*x*	*x*		0	0	2	0	0
633			*x*	*x*	*x*		0	0	2	1	0
634			*x*	*x*	*x*		0	0	2	0	0
635									0	0	0
636	Rinard, *Wayne*	1937[40]	20	15,000	0		0	0	2	0	0
637			*x*	*x*	*x*		0	0	1	0	0
638			*x*	*x*	*x*		0	0	1	0	0
639	Sims, *Wayne*	1941	1,740	3,103,000	490,000		0	0	61	1	0
640			*x*	*x*	*x*		0	0	13	1	0
641			*x*	*x*	*x*		0	0	30	0	0
642									18	0	0
643	Sims North, *Wayne*	1942	1,040	1,068,000	469,000		0	0	37	8	1
644			*x*	*x*	*x*		0	0	24	3	0
645			*x*	*x*	*x*		0	0	0	0	0
646			*x*	*x*	*x*		0	0	3	0	0
647			*x*	*x*	*x*		0	0	9	5	1
648									2	0	0
649	Aden Consolidated, *Wayne, Hamilton*	1938	2,200	4,421,000	537,000		0	0	89	2	0
650			*x*	*x*	*x*		0	0	4	2	0
651			*x*	*x*	*x*		0	0			
652			*x*	*x*	*x*		0	0			
653			*x*	*x*	*x*		0	0	75	0	0
654									10	0	0
655	Burnt Prairie, *White*	1940	600	566,000	187,000		0	0	33	13	0
656			*x*	*x*	*x*		0	0	6	6	0
657			*x*	*x*	*x*		0	0	0	0	0
658			*x*	*x*	*x*		0	0	2	0	0
659			*x*	*x*	*x*		0	0	25	7	0
660									0	0	0
661	Calvin North, *White*	1943	600	478,000	350,000		0	0	42	18	0
662			*x*	*x*	*x*		0	0	1	1	0
663			*x*	*x*	*x*		0	0	23	10	0
664			*x*	*x*	*x*		0	0	0	0	0
665			*x*	*x*	*x*		0	0	1	0	0
666			*x*	*x*	*x*		0	0	9	5	0
667			*x*	*x*	*x*		0	0	2	1	0
668			*x*	*x*	*x*		0	0	4	0	0
669			*x*	*x*	*x*		0	0	1	1	0
670									1	0	0

[38] Abandoned 1942, revived 1943.
[39] Abandoned 1941, revived 1942.
[40] Abandoned 1941.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43]: Flowing	Wells Producing: Oil: Artificial Lift	Wells Producing: Gas	Reservoir Pressure, Lb. per Sq. In.[5]: Initial	Reservoir Pressure: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F[6]	Character of Oil: Sulphur, Per Cent	Producing Formation: Name and Age[7]	Producing Formation: Character	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested: Depth of Hole, Ft.
610	0	245	0												Dev	5,198
611	0	38	0	x	x		39.4	0.14	Aux Vases; MisU	S	P	3,000	20	AL		
612	0	2	0	x	x		x	x	Levias; MisL	OL	P	3,132	10	AC		
613	0	169	0	x	x		39.4	0.16	McClosky; MisL	OL	P	3,159	15	A		
614	0	45	0						[26]							
615	0	1	0												MisL	3,320
616				x	x		x	x	Levias; MisL[25]	OL	P	3,192	5	AC		
617				x	x		x	x	McClosky; MisL[25]	OL	P	3,254	3	AC		
618	0	1	0						[26]							
619	0	2	0												MisL	3,266
620	0	1	0	x	x		39.0	x	Aux Vases; MisU	S	P	3,087	20	x		
621	0	1	0	x	x		x	x	McClosky; MisL	OL	P	3,180	3	x		
622	0	1	0												MisL	3,185
623	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	2,970	13	ML		
624	0	0	0	x	x		x	x	McClosky; MisL	OL	P	3,107	2	MC		
625	0	10	0	x	x		39.0	0.19	McClosky; MisL	OL	P	3,430	6	AC	MisL	3,485
626	0	5	0	x	x		38.0	0.16	McClosky; MisL	OL	P	3,340	13	AC	Dev	5,377
627	0	4	0												MisL	3,354
628	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	3,100	19	ML		
629	0	3	0	x	x		x	x	McClosky; MisL	OL	P	3,236	4	MC		
630	0	7	0												MisL	3,280
631	0	2	0	x	x		37.2	0.14	Aux Vases; MisU	S	P	3,070	15	AL		
632	0	2	0	x	x		x	x	Levias; MisL	OL	P	3,120	8	AC		
633	0	1	0	x	x		x	x	Rosiclare; MisL	OL	P	3,155	10	AC		
634	0	0	0	x	x		31.7	x	McClosky; MisL	OL	P	3,165	10	AC		
635	0	2	0						[26]							
636	0	0	0												MisL	3,154
637	0	0	0	x	x		x	x	Aux Vases; MisU	S	P	2,955	15	AL		
638	0	0	0	x	x		38.5	x	McClosky; MisL	OL	P	3,145	5	AC		
639	0	59	0												MisL	3,487
640	0	17	0	x	x		40.4	0.20	Aux Vases; MisU	S	P	3,013	15	AL		
641	0	29	0	x	x		39.1	x	McClosky; MisL	OL	P	3,150	8	AC		
642	0	13	0						[26]							
643	0	36	0												MisL	3,276
644	0	18	0	x	x		x	x	Aux Vases; MisU	S	P	3,040	10	AL		
645	0	1	0	x	x		x	x	Levias; MisL	OL	P	3,110	8	AC		
646	0	3	0	x	x		x	x	Rosiclare; MisL	OL	P	3,150	8	AC		
647	0	6	0	x	x		37.5	0.19	McClosky; MisL	OL	P	3,185	5	AC		
648	0	8	0						[26]							
649	0	83	0												Dev	5,395
650	0	14	0	x	x		x	x	Aux Vases; MisU	S	P	3,175	15	AL		
651				x	x		x	x	Levias; MisL	OL	P	3,265	6	AC		
652				x	x		x	x	Rosiclare; MisL	OL	P	3,300	8	AC		
653	0	52	0	x	x		40.0	x	McClosky; MisL	OL	P	3,350	8	A		
654	0	17	0						[26]							
655	0	31	0												MisL	3,532
656	0	8	0	x	x		x	x	Aux Vases; MisU	S	P	3,260	18	AL		
657	0	2	0	x	x		39.0	x	Levias; MisL	OL	P	x	5	AC		
658	0	0	0	x	x		x	x	Rosiclare; MisL	OL	P	3,339	7	AC		
659	0	19	0	x	x		37.0	0.28	McClosky; MisL	OL	P	3,400	10	AC		
660	0	2	0						[26]							
661	0	41	0												MisL	3,280
662	0	6	0	x	x		x	x	Buchanan; Pen	S	P	1,088	26	ALf		
663	0	15	0	x	x		30.0	0.29	Biehl; Pen	S	P	1,520	10	ALf		
664	0	1	0	x	x		x	x	Palestine; MisU	S	P	2,140	18	ALf		
665	0	6	0	x	x		x	x	Waltersburg; MisU	S	P	2,260	10	ALf		
666	0	5	0	x	x		34.0	0.30	Tar Springs; MisU	S	P	2,320	12	ALf		
667	0	2	0	x	x		38.4	0.19	Bethel; MisU	S	P	2,815	11	ALf		
668	0	4	0	x	x		x	x	Aux Vases; MisU	S	P	2,880	18	AL		
669	0	1	0	x	x		x	x	McClosky; MisU	OL	P	2,996	16	AC		
670	0	1	0						[26]							

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
671	Carmi, *White*	1940	30	6,000	500		0	0	2	0	0
672			*x*	*x*	*x*		0	0	1	0	0
673			*x*	*x*	*x*		0	0	1	0	0
674	Carmi North, *White*	1942	50	66,000	21,000		0	0	3	0	0
675			*x*	*x*	*x*		0	0			
676			*x*	*x*	*x*		0	0	3	0	0
677									0	0	0
678	Centerville, *White*	1940	60	218,000	31,000		0	0	5	0	0
679	Centerville East, *White*	1941	700	1,270,000	296,000		0	0	44	4	2
680			*x*	*x*	*x*		0	0	24	1	0
681			*x*	*x*	*x*		0	0	3	2	0
682			*x*	*x*	*x*		0	0	1	0	0
683			*x*	*x*	*x*		0	0	5	1	0
684			*x*	*x*	*x*		0	0			
685			*x*	*x*	*x*		0	0	10	0	2
686									1	0	0
687	Concord, *White*	1942	700	602,000	574,000		0	0	46	39	0
688			*x*	*x*	*x*		0	0	15	12	0
689			*x*	*x*	*x*		0	0	9	9	0
690			*x*	*x*	*x*		0	0	8	5	0
691			*x*	*x*	*x*		0	0	1	0	0
692			*x*	*x*	*x*		0	0	10	10	0
693									3	3	0
694	Concord South, *White*	1944	20	*x*	*x*		0	0	2	2	0
695	Epworth, *White*	1941	110	198,000	43,000		0	0	11	0	0
696			*x*	*x*	*x*		0	0	2	0	0
697			*x*	*x*	*x*		0	0	7	0	0
698			*x*	*x*	*x*		0	0	1	0	0
699			*x*	*x*	*x*		0	0	1	0	0
700	Gossett, *White*	1943	40	500	200		0	0	1	0	0
701	Grayville West, *White*	1941	20	40,000	8,000		0	0	3	0	0
702			*x*	*x*	*x*		0	0	1	0	0
703			*x*	*x*	*x*		0	0	2	0	0
704	Herald, *White*	1940	400	208,000	116,000		0	0	24	10	0
705			*x*	*x*	*x*		0	0	4	0	0
706			*x*	*x*	*x*		0	0	2	2	0
707			*x*	*x*	*x*		0	0	4	0	0
708			*x*	*x*	*x*		0	0	5	2	0
709			*x*	*x*	*x*		0	0	2	0	0
710			*x*	*x*	*x*		0	0	7	6	0
711									0	0	0
712	Iron, *White*	1940	1,060	2,941,000	240,000		0	0	69	5	2
713			*x*	*x*	*x*		0	0	0	0	0
714			*x*	*x*	*x*		0	0	5	0	0
715			*x*	*x*	*x*		0	0	38	5	0
716			*x*	*x*	*x*		0	0	2	0	0
717			*x*	*x*	*x*		0	0	1	0	0
718			*x*	*x*	*x*		0	0	20	0	2
719									3	0	0
720	Maunie, *White*	1941	60	29,000	9,000		0	0	3	0	0
721			*x*	*x*	*x*		0	0	2	0	0
722			*x*	*x*	*x*		0	0	1	0	0
723	Maunie North, *White*	1941	240	122,000	64,000		0	0	13	5	0
724			*x*	*x*	*x*		0	0			
725			*x*	*x*	*x*		0	0	0	0	0
726			*x*	*x*	*x*		0	0	5	3	0
727			*x*	*x*	*x*		0	0	1	1	0
728			*x*	*x*	*x*		0	0	0	0	0
729			*x*	*x*	*x*		0	0	5	0	0
730									2	1	0
731	Maunie South, *White*	1941	1,000	1,625,000	260,000		0	0	78	4	0
732			*x*	*x*	*x*		0	0	5	0	0
733			*x*	*x*	*x*		0	0	3	3	0
734			*x*	*x*	*x*		0	0	34	0	0
735			*x*	*x*	*x*		0	0	1	0	0
736			*x*	*x*	*x*		0	0	20	1	0

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil[43]: Flowing	Wells Producing[g] Dec. 1944: Oil[43]: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.[h]: Initial	Reservoir Pressure, Lb. per Sq. In.[h]: Avg./End 1944	Secondary Recovery[k]	Character of Oil[i]: Gravity A.P.I. at 60°F.[6]	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone[o] Tested[p] to End of 1944: Name	Deepest Zone[o] Tested[p] to End of 1944: Depth of Hole, Ft.
671	0	1	0												MisL	3,282
672	0	0	0	x	x		x	x	Levias; MisL	OL	P	3,130	8	MCf		
673	0	1	0	x	x		x	x	McClosky; MisL	OL	P	3,150	4	MCf		
674	0	3	0												MisL	3,418
675				x	x		x	x	Cypress; MisU[25]	S	P	2,935	10	AF		
676	0	2	0	x	x		37.0	0.14	Aux Vases; MisU	S	P	3,230	15	AF		
677	0	1	0						26							
678	0	5	0	x	x		36.8	0.17	McClosky; MisL	OL	P	3,360	5	AC	MisL	3,600
679	0	41	0												MisL	3,365
680	0	22	0	x	x		37.2	0.20	Tar Springs; MisU	S	P	2,500	30	ALf		
681	0	3	0	x	x		x	x	Cypress; MisU	S	P	2,915	10	AL		
682	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,960	18	AL		
683	0	5	0	x	x		x	x	Aux Vases; MisU	S	P	3,080	11	AL		
684				x	x		x	x	Levias; MisL[25]	OL	P	3,175	4	AC		
685	0	8	0	x	x		40.0	x	McClosky; MisL	OL	P	3,250	5	AC		
686	0	2	0						26							
687	1	44	0												MisL	3,115
688	0	15	0	x	x		37.0	x	Tar Springs; MisU	S	P	2,270	15	AL		
689	0	6	0	x	x		x	x	Cypress; MisU	S	P	2,623	10	AL		
690	0	8	0	x	x		x	x	Aux Vases; MisU	S	P	2,905	15	AL		
691	0	1	0	x	x		x	x	Levias; MisL	OL	P	2,930	8	AC		
692	1	9	0	x	x		x	x	McClosky; MisL	OL	P	2,989	10	AC		
693	0	5	0						26							
694	0	2	0	x	x		x	x	Tar Springs; MisU	S	P	2,300	20	MF	MisL	3,096
695	0	10	0												MisL	3,195
696	0	2	0	x	x		x	x	Degonia; MisU	S	P	2,090	6	A		
697	0	6	0	x	x		36.2	x	Clore; MisU	S	P	2,070	15	A		
698	0	1	0	x	x		x	x	Palestine; MisU	S	P	2,100	15	A		
699	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,825	16	x		
700	0	1	0	x	x		x	x	McClosky; MisL	OL	P	3,080	3	MF	MisL	3,090
701	0	2	0												MisL	3,275
702	0	1	0	x	x		37.0	x	Cypress; MisU	S	P	2,870	16	MF		
703	0	1	0	x	x		x	x	McClosky; MisL	OL	P	3,180	10	MF		
704	0	21	0												MisL	3,394
705	0	4	0	x	x		28.0	x	Pennsylvanian; Pen	S	P	1,500	15	A		
706	0	1	0	x	x		x	x	Pennsylvanian; Pen	S	P	1,750	18	MF		
707	0	3	0	x	x		37.2	0.24	Tar Springs; MisU	S	P	2,260	15	AL		
708	0	2	0	x	x		x	x	Cypress; MisU	S	P	2,660	10	AL		
709	0	2	0	x	x		x	x	Bethel; MisU	S	P	2,790	10	AL		
710	0	7	0	x	x		x	x	Aux Vases; MisU	S	P	2,920	13	AL		
711	0	2	0						26							
712	0	60	0												MisL	3,246
713	0	1	0	x	x		x	x	Waltersburg; MisU	S	P	2,270	8	AL		
714	0	4	0	x	x		36.4	x	Tar Springs; MisU	S	P	2,385	12	ALf		
715	0	31	0	x	x		38.4	0.30	Hardinsburg; MisU	S	P	2,500	18	AF		
716	0	2	0	x	x		38.0	x	Cypress; MisU	S	P	2,720	20	AL		
717	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,850	15	AL		
718	0	17	0	x	x		39.0	0.20	McClosky; MisL	OL	P	3,060	15	ACf		
719	0	4	0						26							
720	0	2	0												MisL	3,050
721	0	1	0	x	x		x	x	Pennsylvanian; Pen	S	P	1,310	10	AL		
722	0	0	0	x	x		38.0	x	Palestine; MisU	S	P	2,010	6	AL		
723	0	13	0												MisL	3,120
724				x	x		x	x	Cypress; MisU[25]	S	P	2,660	12	AL		
725	0	1	0	x	x		x	x	Paint Creek; MisU	S	P	2,775	11	AL		
726	0	4	0	x	x		36.5	x	Bethel; MisU	S	P	2,825	15	AL		
727	0	1	0	x	x		x	x	Aux Vases; MisU	S	P	2,940	18	AL		
728	0	1	0	x	x		x	x	Levias; MisL	OL	P	3,015	5	AC		
729	0	2	0	x	x		x	x	McClosky; MisL	OL	P	3,075	16	AC		
730	0	4	0						26							
731	0	75	0												MisL	3,091
732	0	5	0	x	x		37.0	x	Bridgeport; Pen	S	L	1,400	20	AL		
733	0	3	0	x	x		x	x	Degonia; MisU	S	L	1,905	x	AL		
734	0	31	0	x	x		33.8	0.28	Palestine; MisU	S	L	2,010	18	AL		
735	0	1	0	x	x		x	x	Waltersburg; MisU	S	P	2,210	19	AL		
736	0	20	0	x	x		38.0	x	Tar Springs; MisU	S	P	2,245	15	AL		

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e]: To End of 1944	Gas Production: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
737			*x*	*x*	*x*		0	0	2	0	0
738			*x*	*x*	*x*		0	0	8	0	0
739			*x*	*x*	*x*		0	0	1	0	0
740			*x*	*x*	*x*		0	0	1	0	0
741									3	0	0
742	New Harmony Consolidated, *White*....	1939	9,000	28,542,000	4,400,000		0	0	742	21	2
743			*x*	*x*	*x*		0	0	2	2	0
744			*x*	*x*	*x*		0	0	8	0	0
745			*x*	*x*	*x*		0	0	22	0	0
746			*x*	*x*	*x*		0	0	27	0	0
747			*x*	*x*	*x*		0	0	87	0	0
748			*x*	*x*	*x*		0	0	11	0	0
749			*x*	*x*	*x*		0	0	128	2	0
750			*x*	*x*	*x*		0	0	179	9	1
751			*x*	*x*	*x*		0	0	0	0	0
752			*x*	*x*	*x*		0	0	2	0	0
753			*x*	*x*	*x*		0	0	88	1	0
754									188	7	1
755	New Harmony South, *White*..........	1941	60	58,000	13,000		0	0	4	0	0
756			*x*	*x*	*x*		0	0	1	0	0
757			*x*	*x*	*x*		0	0	1	0	0
758			*x*	*x*	*x*		0	0	1	0	0
759			*x*	*x*	*x*		0	0	1	0	0
760	New Haven, *White*..................	1941	250	455,000	68,000		0	0	82	0	0
761			*x*	*x*	*x*		0	0	4	0	0
762			*x*	*x*	*x*		0	0	1	0	0
763			*x*	*x*	*x*		0	0	9	0	0
764			*x*	*x*	*x*		0	0			
765			*x*	*x*	*x*		0	0	5	0	0
766			*x*	*x*	*x*		0	0	1	0	0
767									4	0	0
768	New Haven North, *White*.............	1944	20	3,000	3,000		0	0	2	2	0
769	Phillipstown Consolidated, *White*......	1939	2,000	2,476,000	1,012,000		0	0	129	40	2
770			*x*	*x*	*x*		0	0	3	2	0
771			*x*	*x*	*x*		0	0	6	6	0
772			*x*	*x*	*x*		0	0	7	0	0
773			*x*	*x*	*x*		0	0	11	7	0
774			*x*	*x*	*x*		0	0	2	0	0
775			*x*	*x*	*x*		0	0	2	0	0
776			*x*	*x*	*x*		0	0	0	0	0
777			*x*	*x*	*x*		0	0	40	0	1
778			*x*	*x*	*x*		0	0			
779			*x*	*x*	*x*		0	0	3	3	0
780			*x*	*x*	*x*		0	0	11	5	0
781			*x*	*x*	*x*		0	0	3	1	0
782			*x*	*x*	*x*		0	0	3	0	0
783			*x*	*x*	*x*		0	0	15	5	1
784									23	11	0
785	Stokes, *White*.......................	1939	1,000	1,595,000	412,000		0	0	48	3	0
786			*x*	*x*	*x*		0	0	2	0	0
787			*x*	*x*	*x*		0	0	2	1	0
788			*x*	*x*	*x*		0	0	7	0	0
789			*x*	*x*	*x*		0	0	11	0	0
790			*x*	*x*	*x*		0	0	5	0	0
791			*x*	*x*	*x*		0	0	3	2	0
792			*x*	*x*	*x*		0	0	0	0	0
793			*x*	*x*	*x*		0	0	12	0	0
794									6	0	0
795	Storms, *White*......................	1939	1,740	4,477,000	341,000		0	0	157	1	0
796			*x*	*x*	*x*		0	0	152	0	0
797			*x*	*x*	*x*		0	0	2	1	0
798			*x*	*x*	*x*		0	0	3	0	0
799	Trumbull, *White*....................	1944	10	*x*	*x*		0	0	1	1	0
800	Roland, *White, Gallatin*...............	1940	2,000	4,926,000	839,000		0	0	165	17	0
801			*x*	*x*	*x*		0	0	72	0	0

TABLE 1.—(*Continued*)

Line Number	Wells Producing[a] Dec. 1944 — Oil[42] — Flowing	Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.[5] — Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i] — Gravity A.P.I. at 60°F[6]	Sulphur, Per Cent	Producing Formation — Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944 — Name	Depth of Hole, Ft.
737	0	2	0	x	x		39.0	x	Cypress; MisU	S	P	2,565	8	AL		
738	0	8	0	x	x		x	x	Aux Vases; MisU	S	P	2,845	14	AL		
739	0	1	0	x	x		x	x	Levias; MisU	OL	P	2,865	18	MC		
740	0	1	0	x	x		x	x	McClosky; MisL	OL	P	2,870	2	MC		
741	0	3	0						[26]							
742	1	684	0			G									MisL	3,220
743	0	2	0	x	x		x	x	Jamestown; Pen	S	P	717	13	AL		
744	0	8	0	x	x		x	x	Biehl; Pen	S	P	1,850	20	AL		
745	0	21	0	x	x		37.6	0.49	Waltersburg; MisU	S	P	2,155	20	AL		
746	0	27	0	x	x		36.8	0.19	Tar Springs; MisU	S	P	2,215	20	AL		
747	0	27	0	x	x		39.0	x	Cypress; MisU	S	P	2,570	30	AL		
748	0	11	0	x	x		38.0	x	Paint Creek; MisU	S	P	2,660	20	AL		
749	0	100	0	x	x		36.0	0.24	Bethel; MisU	S	P	2,700	25	A		
750	1	154	0	x	x		36.4	0.19	Aux Vases; MisU	S	P	2,825	15	AC		
751	0	2	0	x	x		x	x	Levias; MisL	OL	P	2,900	5	AC		
752	0	2	0	x	x		x	x	Rosiclare; MisL	SL	P	2,905	10	AC		
753	0	86	0	x	x		39.2	0.20	McClosky; MisL	OL	P	2,925	8	AC		
754	0	193	0						[26]							
755	0	2	0												MisL	3,207
756	0	1	0	x	x		x	x	Waltersburg; MisU	S	P	2,250	20	MF		
757	0	0	0	x	x		x	x	Tar Springs; MisU	S	P	2,355	16	MF		
758	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,820	15	MF		
759	0	0	0	x	x		38.0	x	McClosky; MisL	OL	P	3,010	8	MF		
760	0	22	0												MisL	2,900
761	0	4	0	x	x		36.4	0.27	Tar Springs; MisU	S	P	2,100	10	ALf		
762	0	1	0	x	x		38.0	x	Hardinsburg; MisU	S	P	2,250	7	ALf		
763	0	8	0	x	x		38.0	x	Cypress; MisU	S	P	2,435	12	ALf		
764				x	x		x	x	Bethel; MisU[25]	S	P	2,630	9	ALf		
765	0	3	0	x	x		39.0	x	Aux Vases; MisU	S	P	2,715	17	ALf		
766	0	2	0	x	x		38.0	x	McClosky; MisU	OL	P	2,830	6	MC		
767	0	4	0						[26]							
768	0	2	0	x	x		x	x	Tar Springs; MisU	S	P	2,175	10	ML	MisL	2,986
769	0	116	0												Dev	5,350
770	0	3	0	x	x		x	x	Pennsylvanian; Pen	S	P	795	10	MF		
771	0	6	0	x	x		x	x	Pennsylvanian; Pen	S	P	1,340	10	MF		
772	0	7	0	x	x		36.2	0.22	Pennsylvanian; Pen	S	P	1,450	15	MF		
773	0	8	0	x	x		x	x	Degonia; MisU	S	P	1,975	10	MF		
774	0	4	0	x	x		36.0	x	Clore; MisU	S	P	2,010	10	MF		
775	0	2	0	x	x		36.0	x	Palestine; MisU	S	P	2,050	10	MF		
776	0	1	0	x	x		x	x	Waltersburg; MisU	S	P	2,280	x	MF		
777	0	35	0	x	x		36.0	x	Tar Springs; MisU	S	P	2,295	15	ALf		
778				x	x		x	x	Cypress; MisU	S	P	2,720	12	AF		
779	0	9	0	x	x		x	x	Paint Creek; MisU	S	P	2,780	9	AF		
780	0	14	0	x	x		x	x	Bethel; MisU	S	P	2,810	12	AF		
781	0	8	0	x	x		39.4	x	Aux Vases; MisU	S	P	2,880	15	AF		
782	0	0	0	x	x		x	x	Rosiclare; MisL	SL	P	2,960	10	AC		
783	0	8	0	x	x		38.2	0.21	McClosky; MisL	OL	P	3,000	6	AC		
784	0	11	0						[26]							
785	0	48	0												MisL	3,204
786	0	3	0	x	x		x	x	Tar Springs; MisU	S	P	2,295	16	MF		
787	0	1	0	x	x		x	x	Cypress; MisU	S	P	2,660	12	MF		
788	0	19	0	x	x		x	x	Paint Creek; MisU	S	P	2,800	22	AF		
789	0	1	0	x	x		x	x	Bethel; MisU	S	P	2,813	8	AF		
790	0	4	0	x	x		x	x	Aux Vases; MisU	S	P	2,890	15	AF		
791	0	4	0	x	x		x	x	Levias; MisL	OL	P	3,035	5	AC		
792	0	1	0	x	x		x	x	Rosiclare; MisL	SL	P	x	x	AC		
793	0	5	0	x	x		35.8	0.26	McClosky; MisL	OL	P	3,070	10	AC		
794	0	11	0						[26]							
795	0	143	0												MisL	3,173
796	0	138	0	x	x		32.1	0.28	Waltersburg; MisU	S	P	2,230	11	AL		
797	0	2	0	x	x		x	x	Cypress; MisU	S	P	2,655	10	ALf		
798	0	3	0	x	x		x	x	Paint Creek; MisU	S	P	2,805	14	ML		
799	0	1	0	x	x		x	x	Cypress; MisU	S	P	2,830	x	A	MisU	2,858
800	0	154	0												Dev	5,225
801	0	62	0	x	x		x	x	Waltersburg; MisU	S	P	2,170	15	AL		

In 1943, some 22,905 acres were added, 2,690 acres in new fields and 20,215 acres in older fields.

Drilling

During the year, 1991 wells were drilled for oil or gas. In addition five completions of gas-input wells and six of wells for salt-water disposal were reported, and there was an unknown number of unreported input wells. Of the 1991 wells drilled for oil or gas, 1217 were oil wells, 6 were gas wells, and 768 were dry holes. Producing wells made up 61 per cent of the wells drilled, an increase of 2 per cent over 1943. Of the total number of wells drilled, 430 are classified as wildcat. Of this number 70, or 16 per cent, were successful in obtaining production, as compared with 94 successful completions (20 per cent) in 1943 (Tables *2A* and *2B*). Of the 430 wildcat wells completed in 1944 (Table 4), 261 were more than 2 miles from production, and of these, 28 (or 11 per cent) were successful. For comparison, 243 wildcat wells were more than 2 miles from production in 1943, and of these, 29 (or 12 per cent) were successful. Table *2D* is a list of selected dry wildcat wells, including deep-pool tests and wildcats in nonproducing parts of the state.

A summary of drilling by counties for the year is given in Table 5.

Exploration Methods

Of the 430 wildcat wells drilled (Table 4), 18 per cent of the 364 known to have been located by scientific methods were successful, as compared with 22 per cent success for wildcats thus located in 1943. The total footage of wildcat wells drilled in 1944 was 1,073,714 ft. of which a total of 192,167 ft., or 18 per cent, was drilled in successful wells.

Subsurface geology and seismograph surveys were used in locating 85 per cent of the wildcat wells drilled in 1944 in Illinois. New pools were discovered by the following methods: subsurface geology, 15; seismograph surveys, 7; seismograph and subsurface geology, 3; nonscientific, 3.

Table 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
802			x	x	x		0	0	4	0	0
803			x	x	x		0	0	12	7	0
804			x	x	x		0	0			
805			x	x	x		0	0	17	2	0
806			x	x	x		0	0	20	1	0
807			x	x	x		0	0			
808			x	x	x		0	0	2	0	0
809									38	7	0
810	Mill Shoals, *White, Hamilton, Wayne*...	1939	1,840	3,452,000	476,000		0	0	134	19	1
811			x	x	x		0	0	107	16	1
812			x	x	x		0	0			
813			x	x	x		0	0			
814			x	x	x		0	0	23	2	0
815									4	1	0
816	Total for fields after Jan. 1, 1937[42].....		173,485	642,407,000	72,946,000		6,126	600	14,287	1,187	193
817	Total for Illinois[42].....................		329,050	1,103,768,000	77,413,000		8,552	615	35,088	1,235	668

[42] Total from U. S. Bureau of Mines monthly report.

The number of seismograph parties operating throughout the year, by months, was as follows:

Jan.	5	July	2
Feb.	3	Aug.	2
Mar.	4	Sept.	2
April	4	Oct.	2
May	3	Nov.	1
June	3	Dec.	2

Total party months.................... 33

In terms of party months, the amount of seismograph work done in Illinois in 1944 dropped to about 40 per cent of the 1943 total, which was 85 party months.

No pre-Mississippian pools or new producing formations were discovered in Illinois in 1944. Dry Devonian tests were drilled in three Mississippian pools: Dale-Hoodville, Johnsonville, and Mayberry; and as edge wells of two other pools: Dix and Johnson South. None of the Devonian tests that were drilled in areas of shallower production found any large porous zone in the Devonian comparable with that which produces in the Salem and Centralia fields. A selected list of dry tests for the year is given in Table 2*D*.

A noteworthy deep test was the Ohio Oil Company's Shaw No. 1 well near Tuscola, Ill., which was dry and was abandoned in December 1944, at a total depth of 4151 ft., and was finished in the Mt. Simon sandstone of the Cambrian system, top of the Mt. Simon at 4045 ft. Oil stains were found in the "Trenton" limestone but no oil shows were found below that. This well was located on top of a large dome of several hundred feet closure in the LaSalle anticlinal belt, and in an area where the uppermost bedrock is Devonian limestone.

Development

Drilling during 1944 was concentrated in eight counties: Clay, Edwards, Hamilton, Jefferson, Richland, Wabash, Wayne, and White. Wayne County led in activity with 330 completions, of which 242 were producing wells. Jefferson ranked first in discoveries for the year with four new pools, including the three that had produced the most oil by the end of the year: Boyd, Divide West, and Roaches North. Fields in which the greatest number of producing

Table 1.—(*Continued*)

	Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.[5]			Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Oil[43]															
Line Number	Flowing	Artificial Lift	Gas	Initial	Avg./End 1944	Secondary Recovery[h]	Gravity A.P.I. at 60°F[6]	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
802	0	4	0	x	x		31.7	0.25	Tar Springs; MisU	S	P	2,240	12	AL		
803	0	11	0	x	x		32.0	x	Cypress; MisU	S	P	2,560	15	AL		
804				x	x		x	x	Paint Creek; MisU[25]	S	P	2,750	12	A		
805	0	16	0	x	x		39.0	x	Bethel; MisU	S	P	2,760	17	A		
806	0	19	0	x	x		x	x	Aux Vases; MisU	S	P	2,880	18	AL		
807				x	x		x	x	Levias; MisL[25]	OL	P	2,950	8	AC		
808	0	2	0	x	x		x	x	McClosky; MisL[26]	OL	P	2,970	5	AC		
809	0	40	0													
810	0	130	0												MisL	3,520
811	0	103	0	x	x		39.8	0.14	Aux Vases; MisU	S	P	3,220	16	A		
812				x	x		x	x	Levias; MisL[25]	OL	P	3,317	11	AC		
813				x	x		x	x	Rosiclare; MisL[25]	SL	P	3,344	8	AC		
814	0	23	0	x	x		38.0	0.16	McClosky, MisL	OL	P	3,440	5	AC		
815	0	4	0													
816	171	12,335	64													
817	171	24,355	73													

TABLE 2.—*Important Wells Drilled in Illinois in* 1944

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
	A. Discovery Wells of New Fields									
1	Bennington South	Edwards	Nash Redwine, G. C. Jones 1	31-1N-10E	3,253	3,238	McClosky	132 + 67	7-18-44	1
2	Bible Grove East	Clay	Wisc. Ref. and Doran, Murvin 1	22-5N-7E	2,517	2,508	Cypress	156	12-19-44	2
3	Bogota South	Jasper	Schuller and Witt, Lourance 1	3-5N-9E	3,065	3,054	McClosky	57	7-4-44	1
4	Boyd	Jefferson	Cameron, Bizot 1	30-1S-2E	2,063	2,050	Bethel	167	8-22-44	15
5	Calhoun	Richland	Phillips Petr. Co., Jennings 1	6-2N-10E	3,280	3,166	Levias	178	8-22-44	6
6	Calhoun North	Richland	Pure Oil Co., Koertge 1	33-3N-10E	3,276	3,165; 3,184	Rosiclare; McClosky	149 + 97	1-2-45	1
7	Concord South	White	Great Lakes Carbon, Burris 1	7-7S-10E	3,113 (PB 2,411)	2,313	Tar Springs	50	9-12-44	2
8	Divide West	Jefferson	Texas Company, W. Green 1	15-1S-3E	2,862	2,752	McClosky	85	2-29-44	11
9	Ewing	Franklin	Central Pipe Line, Rose 1	4-5S-3E	2,980	2,973	McClosky	146 + 15	12-5-44	1
10	Fitzgerrell	Jefferson	Texas Company, Inland Steel 1	25-4S-1E	3,012 (PB 2,776)	2,756	Bethel	53 + 46	12-12-44	1
11	Hoodville East	Hamilton	Nat. Assoc. Petr., Stocker 1	33-5S-7E	3,387	3,364	McClosky	80 + 10	6-13-44	0
12	Keensburg South	Wabash	Central Pipe Line, Garst 1	27-2S-13W	2,728	2,713	Levias	173	6-13-44	2
13	Lancaster East	Wabash	Greauling, Case 1	36-2N-13W	2,630 (PB 1,761)	1,745	Biehl	5	12-12-44	1
14	Maplegrove East	Edwards	Texas Company, C. Lambright 1	1-1N-10E	3,242	3,215	McClosky	133 + 42	6-6-44	3
15	Mt. Erie North	Wayne	Jablonski, Yorndorf-Ascher 1	3-1N-9E	3,226	3,100	Aux Vases	47	1-25-44	4
16	New Haven North	White	Sohio, Union Cen. Life Ins. 1-A	10-7S-10E	2,183	2,174	Tar Springs	40	8-1-44	2
17	New Haven West	Gallatin	Oil Management, Goforth 2	27-7S-10E	2,115	2,098	Tar Springs	184	8-15-44	8
18	Newton	Jasper	Texas Company, Huddlestun 1	13-6N-9E	3,022	2,929	McClosky	39 + 22	1-2-45	1
19	Olney East	Richland	Texas Company, Wright 1	24-4N-10E	3,094	3,080	McClosky	416	12-19-44	1
20	Roaches North	Jefferson	Texas Company, Kasban 1	8-2S-1E	2,255	2,103	Rosiclare	221 + 10	8-15-44	28
21	Sailor Springs East	Clay	Magnolia Petr. Co., Mary A. Rinnert 1	33-4N-8E	2,718	2,690	Cypress	32	8-29-44	9
22	Santa Fe	Clinton	Texas Company, Althoff 1	29-1N-3W	2,512 (PB 974)	953	Cypress	5½ + 2	12-5-44	1
23	Sumner	Lawrence	Texas Company, M. D. Smith 1	16-4N-13W	2,359	2,261	McClosky	65	8-22-44	1
24	Thackeray	Hamilton	Nat. Assoc. Petr., Johnson 2	10-5S-7E	3,402	3,384	Aux Vases	60	8-8-44	3
25	Thompsonville North	Franklin	Deep Rock, Kirk Tr. 1	15-7S-4E	3,152	3,113	Aux Vases	110 + 3	12-19-44	1
26	Trumbull	White	Lewis, Burkhard 1	18-5S-9E	2,858	2,830	Cypress	192	1-2-45	1
27	West End	Hamilton	Sinclair-Wyoming, Russell 1	17-7S-5E	3,150	3,131	Aux Vases	425	1-2-45	1
28	Whittington West[b]	Franklin	Murchison, Franklin County Coal 1	11-5S-2E	2,942	2,752	Levias	8 + 5	12-14-43	3
29	Willow Hill	Jasper	Pure Oil Co., Dhom "A" 1	34-7N-10E	2,715	2,665	McClosky	213	11-28-44	1
	B. Discovery Wells of Extensions to Pools									
1	Albion Consolidated	Edwards	Superior, Blood A-1	1-3S-10E	3,263	2,997; 3,109; 3,045	Bethel; Aux Vases; Renault	88	6-6-44	
2	Belle Prairie	Hamilton	Phillips Petr. Co., Leach 1	12-4S-6E	3,450	3,426	McClosky	85 + 85	10-3-44	
3	Belle Prairie	Hamilton	Shell Oil Co., Shepard 1	2-4S-6E	3,432	3,351	McClosky	61 + 15	5-23-44	
4	Bible Grove	Effingham	Schulman Bros., F. W. Veith 1	34-6N-7E	2,541	2,528	Cypress	85	11-21-44	
5	Browns	Edwards	Kingwood, Iles Tr. 1	4-2S-14W	3,112 (PB 3,020)	3,013	McClosky	12 + 31	11-7-44	
6	Browns South	Edwards	Mitchell, Henderson 1	5-2S-14W	2,869	2,850	Bethel	50	12-5-44	
7	Bone Gap	Edwards	Schrack, McDowell 1	6-1S-14W	3,188	3,153	McClosky	30	7-25-44	

[a] Oil and water.
[b] Discovered in 1943; named 2-3-44.

TABLE 2.—(*Continued*)

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
8	Boylston Consolidated	Wayne	Pure Oil Co., Wayne County Farm 1	24-1S-7E	3,332	3,312	McClosky	382 + 176	7-11-44	
9	Calhoun	Richland	Climer (Ill. Prod.), Richards 1	7-2N-10E	3,188	3,157	McClosky	30	12-12-44	
10	Calvin North	White	Nat. Assoc. Petr., Bisch 1	30-3S-14W	3,120	1,534	Pennsylvanian	43 + 43	5-16-44	
11	Carlinville North	Macoupin	Gill, Wilson 1	29-10N-7W	469	462	Pottsville	8	11-14-44	
12	Clay City Consol.	Wayne	Pure Oil Co., Fitch 1	16-1N-8E	3,180	3,071	McClosky	55 + 92	3-28-44	
13	Clay City Consol.	Wayne	Pure Oil Co., Jones 1	24-1N-8E	3,215 (PB 3,048)	3,010	Aux Vases	48	12-5-44	
14	Clay City Consol.	Wayne	Pure Oil Co., Miller "A" 1	24-2N-8E	3,060	2,998	McClosky	70	9-12-44	
15	Clay City Consol.	Wayne	Pure Oil Co., Thompson "A" 1	26-2N-7E	3,082	3,026	McClosky	427 + 38	6-20-44	
16	Clay City West	Clay	Amsco, McAllister 1	3-2N-7E	3,150	2,700	Cypress	29 + 4	10-3-44	
17	Cowling	Edwards	Wickham, Schroeder 1	27-2S-14W	3,004	2,971	McClosky	55 + 100	8-1-44	
18	Geff	Wayne	Pure Oil Co., Molt "A" 1	31-1N-8E	3,158	3,089	Rosiclare	110 + 113	4-18-44	
19	Goldengate Consolidated	Wayne	Cities Service, Kletzker 1	4-3S-9E	3,441	3,298; 3,338	Levias; Rosiclare	130 + 10	12-5-44	
20	Iola	Clay	Texas Company, Rose 1	10-5N-5E	2,559	2,145	Cypress	27 + 5	10-24-44	
21	Keensburg South	Wabash	Fox Bros., Thompson 2	3-3S-13W	1,161	1,144	Pennsylvanian	35 + 30	8-8-44	
22	Lancaster	Wabash	Greauling, Cooper 1	33-2N-13W	2,574	2,548	Bethel	170	6-6-44	
23	Lancaster West	Edwards	Martin, Bradham 1	3-1N-14W	3,125 (2,990)	2,976	Levias	8 + 10	11-14-44	
24	Lawrence	Lawrence	Big Four and Ashland, Sumner-Briggs 1	13-3N-13W	2,048	2,022; 2,038	Levias; McClosky	22	10-24-44	
25	Marine	Madison	Obering, Bird 1	8-4N-6W	1,747	1,719	Silurian	45	7-25-44	
26	Mill Shoals	Wayne	Robinson Puckett, Felix 1	12-3S-7E	3,258	3,240	Aux Vases	129	2-15-44	
27	Mt. Carmel	Wabash	Shell Oil Co., Dunkel 1	33-1N-12W	2,435 (PB 2,114)	1,993	Cypress	35 + 14	8-8-44	
28	Mt. Erie	Wayne	Pure Oil Co., Wilson Consol. "A" 1	10-1S-8E	3,235	3,217	McClosky	43 + 115	4-18-44	
29	Mt. Erie North	Wayne	Dolly and Reyfield, Amsbury 1	9-1N-9E	3,247	3,246	McClosky	210 + 15	7-18-44	
30	Mt. Erie North	Wayne	Dolly and Reyfield, Totten-Rothrock 1	5-1N-9E	3,270	3,209	McClosky	20 + 650	12-5-44	
31	New Haven North	White	Sohio Oil Co., Pearce et al. 1	3-7S-10E	2,186	2,176	Tar Springs	18	8-22-44	
32	Noble	Richland	Pure Oil Co., Chaffin "C" 1	1-2N-8E	3,110	2,970	McClosky	113 + 88	8-29-44	
33	Noble	Richland	Pure Oil Co., Sharp "B" 1	2-2N-8E	2,982	2,956	McClosky	595	12-12-44	
34	Noble	Richland	Pure Oil Co., Smith "A" 1	35-3N-8E	3,002	2,968	McClosky	285	7-18-44	
35	Patton West	Wabash	Olds Oil Co., Stillwell 2	28-1N-12W	2,387 (PB 2,040)	2,011	Cypress	5	11-28-44	
36	Patton West	Wabash	Skiles Schmitt 1	20-1N-12W	2,351	2,331	McClosky	345 + 15	2-15-44	
37	Roaches North	Jefferson	Nat. Assoc. Petr., Casner Oil and Gas 1	5-2S-1E	1,900	1,885	Bethel	146	9-12-44	
38	Schnell	Richland	Pure Oil Co., Kurtz 1	19-3N-9E	3,046	2,968	McClosky	232	7-4-44	
39	Schnell	Clay	Wicklund, McCauley 2	23-3N-8E	2,976	2,974	McClosky	225	8-8-44	
40	Sesser	Franklin	Jarvis, Old Ben Coal 1A-2	29-5S-2E	2,866	2,836; 2,856	Rosiclare; McClosky	40 + 60	11-28-44	
41	Storms	White	Skelly Oil Co., McCarty 1	7-6S-10E	3,173 (PB 2,705)	2,698	Cypress	17 + 30	10-24-44	
42	Whittington West	Franklin	Randall, U. S. Coal and Coke 1	14-5S-2E	2,716	2,679	Aux Vases	42	9-12-44	

C. DISCOVERY WELLS OF ADDITIONAL PRODUCING ZONES IN POOLS

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
1	Albion Consolidated	Edwards	Carter Oil Co., Schmittler 1	12-3S-10E	3,188	2,650	Hardinsburg	756 + 60[c]	12-12-44	
2	Albion Consolidated	Edwards	Schrack, Scott Heirs 1	36-2S-10E	2,069	2,059	Biehl	114	2-8-44	
3	Albion Consolidated	Edwards	Superior, Mussett 5	12-3S-10E	3,119	2,127	Degonia	150 + 2[c]	12-12-44	
4	Albion Consolidated	Edwards	Superior, Wick 1	25-2S-10E	3,181	2,448	Tar Springs	218 + 27[c]	5-9-44	
5	Albion Consolidated	Edwards	Superior, Willett 2	30-2S-11E	3,123	2,944	Renault	125[c]	4-11-44	

[c] Production from two or more pays.

TABLE 2.—(*Continued*)

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
6	Bennington	Edwards	Tidewater, Van Schoick 1	18-1N-10E	3,235	3,214	McClosky	145	12-5-44	
7	Benton North	Franklin	Markham, Old Ben Coal 1	1-6S-2E	2,458	2,427	Cypress	10 + 68	10-17-44	
8	Boyd	Jefferson	Superior, Price 4	19-1S-2E	2,158	2,134	Aux Vases	453	10-31-44	
9	Browns	Edwards	Superior, Lipper 2	28-1S-14W	2,948 (PB 2,783)	2,778	Bethel	170	2-1-44	
10	Browns	Edwards	Superior, Lipper 6	28-1S-14W	3,071	2,994	McClosky	444	7-11-44	
11	Bungay	Hamilton	Nat. Assoc. Petr., York-Tibbs 2	35-4S-7E	3,442	3,428	McClosky	20	3-14-44	
12	Burnt Prairie	White	New Penn Develop., Whitlow 4	28-3S-9E	3,430		Aux Vases	50	8-1-44	
13	Calhoun	Richland	Phillips, Richland 1	6-2N-10E	3,163	3,150	McClosky	577	10-17-44	
14	Calvin North	White	White Eagle, Woodham 1	30-3S-14W	3,082	2,996	McClosky	42	12-5-44	
15	Coil W	Jefferson	Gulf, Donoho 1	23-1S-4E	2,961 (PB 2,814)	2,720	Aux Vases	210 + 5[c]	5-16-44	
16	Concord	White	Great Lakes Carbon, Tuley 1	21-6S-10E	2,646	2,623	Cypress	80 + 25	2-15-44	
17	Covington	Wayne	Deep Rock, Harper 1	32-1S-7E	3,297	3,244	Rosiclare	88 + 18[c]	2-1-44	
18	Cowling	Edwards	Wickham, Schroeder 1	27-2S-14W	3,004	2,971	McClosky	55 + 100	8-1-44	
19	Divide West	Jefferson	Texas, Green 4	22-1S-3E	2,854 (PB 2,800)	2,682	Levias	129 + 33[c]	10-10-44	
20	Flora	Clay	Tidewater, Graham-Hill 1	13-3N-6E	2,985	2,874	Aux Vases	42[c]	1-25-44	
21	Geff	Wayne	Pure, Molt "A" 1	31-1N-8E	3,158	3,089	Rosiclare	110 + 113	4-18-44	
22	Grayville	White	Yingling, Potter Comm. 1	20-3S-14W	2,790	2,090	Palestine	56	1-25-44	
23	Keensburg South	Wabash	Fox Bros., Thompson 2	3-3S-13W	1,161	1,144	Pennsylvanian	35 + 30	8-8-44	
24	Lancaster	Wabash	Schrack, Seibert 1	4-1N-13W	2,750	2,669	Levias	90[c]	6-27-44	
25	Markham City North	Jefferson	Central Pipe Line, J. T. Henry 2	13-2S-4E	2,956	2,943	Aux Vases	170 + 20	1-25-44	
26	Mattoon	Coles	Beckman, Herman Comm. 1	25-12N-7E	2,064	2,048	Rosiclare	21	2-29-44	
27	Maunie North	White	Continental Oil, Brown 1	25-5S-10E	3,107	3,015	Levias	16	5-13-44	
28	Mt. Erie	Wayne	Gulf, Wynona-Blackburn 1	12-1S-8E	3,114	3,058	Levias	132 + 14[c]	5-2-44	
29	Mt. Erie North	Wayne	Dolly and Reyfield, Amsbury 1	9-1N-9E	3,247	3,246	McClosky	210 + 15	7-18-44	
30	Patton West	Wabash	Bell Bros., Green 3	29-1N-12W	2,325	2,313	Levias	7 + 50[c]	9-12-44	
31	Patton West	Wabash	Luttrell, Litherland 1	20-1N-12W	2,351 (PB 2,170)	2,022	Cypress	15	3-7-44	
32	Patton West	Wabash	Luttrell, Litherland 1	20-1N-12W	2,351 (PB 2,170)	2,139	Bethel	15	3-7-44	
33	Patton West	Wabash	Shell, Woods et al 1	20-1N-12W	2,112 (PB 1,565)	1,542	Biehl	50 + 34	2-15-44	
34	Patton West	Wabash	Williams, Rosignal 1	20-1N-12W	2,300	2,284	Aux Vases	95	5-16-44	
35	Phillipstown Consolidated	White	Gulf, Garfield Parson 1	7-4S-14W	2,826	2,776	Paint Creek	60 + 10	2-29-44	
36	Roaches North	Jefferson	Texas, Kasban 2	8-2S-1E	2,138	1,933	Bethel	195	8-29-44	
37	Sesser	Franklin	Jarvis, Old Ben Coal 1 A-2	29-5S-2E	2,866	2,836	Rosiclare	40 + 60	11-28-44	
38	Sesser	Franklin	Jarvis, Old Ben Coal 1 A-2	29-5S-2E	2,866	2,856	McClosky	40 + 60	11-28-44	
39	Whittington West	Franklin	Randall, U. S. Coal and Coke 1	14-5S-2E	2,716	2,679	Aux Vases	42	9-12-44	

TABLE 2.—(*Continued*)

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
			D. SELECTED LIST OF DRY TESTS							
1		Bond	Magnolia, L. V. Hunter 1	15-6N-3W	2,386	2,276	Dutch Creek (Dev)		11-14-44	
2		Bond	Texas, Enloe 1	6-4N-2W	3,397	3,372	Trenton		5-2-44	
3		Bond	Texas, F. M. Miller 1	22-6N-2W	2,485	2,416	Clear Creek (Dev)		11-28-44	
4		Bond	Union Prod. Petr., Acconero 1	26-4N-4W	3,170				11-28-44	
5		Clark	Jansen, Carpenter 1	9-9N-12W	2,735	2,697	Devonian		6-6-44	
6		Clark	Texas, Coldren 1	4-11N-11W	2,406	2,236	Devonian		10-3-44	
7		Clark[d]	Wright, Hight 1	32-9N-14W	2,570	2,503	Devonian		10-17-44	
8		Clinton	Stanolind, Phillips 1	4-2N-3W	2,513	2,391	Devonian		2-1-44	
9		Clinton	Strickland, Haake 1	32-2N-3W	2,602	2,498	Devonian		12-19-44	
10		Clinton	Texas, Schumacher 1	29-3N-4W	2,426	2,225	Devonian		5-2-44	
11		Douglas	Ohio, Shaw 1	36-16N-8E	4,151	4,045	Mt. Simon		1-2-45	
12		Fayette	Texas, Sheridan-Stokes 1	7-8N-1E	3,663	3,607	Plattin		1-11-44	
13		Ford	Herndon, W. J. Fecht 1	33-26N-9E	2,237	2,075	Oneota		2-1-44	
14		Greene	Beatrice Creamery, Chicago Cold Storage 1	26-12N-13W	1,100	1,063	St. Peter		5-2-44	
15		Greene	Johnson, Waller 1	12-11N-10W	1,100	1,001	Devonian		5-23-44	
16		Hamilton[e]	Texas, Davis 14	7-6S-7E	5,358	5,020	Devonian		12-5-44	
17		Hancock	Herndon, M. D. Laffey 1	17-3N-7W	3,025	2,760	Mt. Simon		3-14-44	
18		Henderson	Northern Ordnance, Adams 1	28-8N-4W	323				6-27-44	
19		Henderson	Northern Ordnance, Bohan 1	18-8N-4W	729	698	Maquoketa		7-18-44	
20		Henderson	Northern Ordnance, Covert 1	35-8N-4W	725				8-1-44	
21		Henderson	Northern Ordnance, Likely 1	1-9N-5W	410	405	Maquoketa		8-22-44	
22		Henderson	Northern Ordnance, Pendarvis 1	17-9N-4W	446				6-27-44	
23		Henderson	Northern Ordnance, Pendarvis 1	23-9N-4W	492				8-22-44	
24		Henderson	Northern Ordnance, Tubbs 1	22-9N-4W	390				7-11-44	
25		Henderson	Northern Ordnance, Tubbs 2	22-9N-4W	605				8-22-44	
26		Henderson	Northern Ordnance, Schenck 1	15-8N-4W	674	667	Maquoketa		12-5-44	
27		Jackson	Magnolia, Froemling-Reuscher 1	11-7S-4W	3,582	3,421	"Trenton"		6-27-44	
28		Jefferson[f]	Nash Redwine, V. Laux 1	15-1S-2E	3,765	3,611	Devonian		6-20-44	
29		Kendall	Herndon, R. Proctor 1	36-36N-8E	2,328		Mt. Simon		2-2-44	
30		McDonough	Northern Ordnance, Champion 1	9-6N-3W	642				11-7-44	
31		McDonough	Northern Ordnance, Deems 1	26-7N-4W	760				11-14-44	
32		Madison	Magnolia, Plocker 1	10-3N-5W	2,897	2,876	Plattin		12-19-44	
33		Montgomery	Malone, Todt 1	21-11N-4W	632				4-4-44	
34		Montgomery	Texas, Long 1	27-11N-5W	2,525	2,359	"Trenton"		6-13-44	
35		Montgomery	Texas, Springfield Marine Bank 1	32-10N-3W	2,714	2,636	"Trenton"		5-2-44	
36		Randolph	General Oil and Gas, Schmoll 3	27-4S-7W	450				8-22-44	
37		Randolph	General Oil and Gas, Schmoll 4	27-4S-7W	427				11-28-44	
38		Randolph	McHughes, Wilson 1	23-6S-6W	757	635	Aux Vases		4-18-44	
39		St. Clair	Braun, Munier 1	27-1S-8W	309	185	Cypress		2-29-44	
40		St. Clair	Sinclair-Wyoming, Baer 1	23-2N-6W	2,575	2,459	"Trenton"		10-24-44	
41		St. Clair	Skelly, Schickedanz 1	12-3S-6W	2,805	2,684	"Trenton"		8-15-44	

[d] Old well deepened. Near Johnson South field.
[e] In Dale-Hoodville field.
[f] In Dix field.

TABLE 2.—(*Continued*)

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[a]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 2, 1945
42		St. Clair	Young, McCurdy 3	32-3S-6W	530	506	Cypress		3-28-44	
43		St. Clair	Young, McCurdy 4	29-3S-6W	618	590	Bethel		7-25-44	
44		Saline	Brehm, Webb 1	28-8S-6E	3,063	2,855	St. Genevieve		12-19-44	
45		Saline	Jarvis and Marcell, R. Raley 1	10-10S-6E	2,074	1,953	Cypress		1-25-44	
46		Saline	Jarvis and Marcell, Sisk 1	15-10S-6E	1,520	1,498	Waltersburg		3-21-44	
47		Saline	Magnolia, Pruett 1	7-9S-6E	2,886	2,615	St. Genevieve		7-11-44	
48		Schuyler	Amberg and Miller, Taylor 1	30-1N-1W	630				6-20-44	
49		Schuyler	Northern Ordnance, F. B. Greuel 1	7-3N-1W	684	617	Maquoketa		8-15-44	
50		Schuyler	Northern Ordnance, E. Payne 1	3-3N-2W	756				10-10-44	
51		Schuyler	Northern Ordnance, A. Yaap 1	1-3N-2W	783	664	Devonian		9-12-44	
52		Shelby	Luttrell, McAndrew 1	15-10N-6E	2,314	2,298	St. Louis		10-31-44	
53		Shelby	Lynch, Amling 1	20-12N-2E	1,666	1,558	St. Genevieve		6-27-44	
54		Shelby	Texas, Noffke 1	31-11N-6E	2,182	2,070	St. Genevieve		3-28-44	
55		Shelby	Thorpe, Hosteler 1	33-11N-4E	2,034	1,888	St. Genevieve		7-11-44	
56		Union	Nation Oil, Gray 1	2-11S-1E	1,949	1,730	St. Genevieve		2-22-44	
57		Washington	Hubbard, Sandheindrich 1	18-2S-5W	952	920	Aux Vases		2-1-44	
58		Washington	Ruwalt, Brinkman 1	14-2S-5W	2,475	2,290	Devonian		2-8-44	
59		Wayne[g]	Texas, Draper 1	8-3S-6E	5,377	5,169	Devonian		6-6-44	
60		Wayne[h]	Texas, Greathouse 1	27-1N-6E	5,200	5,186	Clear Creek (Dev)		11-14-44	
61		Will	Livengood, E. L. Herren 1	23-36N-9E	1,958	1,904	Mt. Simon		11-14-44	
62		Williamson	Browning, Hayton 1	32-9S-1E	2,060	1,958	St. Genevieve		12-12-44	
63		Williamson	Superior, Pulley et al. 1	13-9S-3E	2,790	2,776	St. Louis		4-18-44	

[g] In Mayberry field. Old well deepened, plugged back to McClosky producer.
[h] Old well deepened. In Johnsonville field.

TABLE 3.—*Completions and Production in Illinois since January 1, 1936*

Period of Time	Number of Completions[a]	Number of Producing Wells	Production, Thousands of Barrels		
			New Fields[b]	Old Fields[b,c]	Total[d]
1936	93	52			4,445
1937	449	292	2,884	4,542	7,426
1938	2,541	2,010	19,771	4,304	24,075
1939	3,675	2,970	90,908	4,004	94,912
1940	3,829	3,080	142,969	4,678	147,647
1941	3,838	2,925	128,993	5,145	134,138
1942	2,016	1,179	101,837	4,753	106,590
1943	1,791	1,087[e]	77,586	4,674	82,256
1944: Jan.	127	78	6,426	357	6,783
Feb.	130	86	6,030	361	6,391
Mar.	113	69	6,315	389	6,704
Apr.	138	88	5,983	357	6,340
May	127	79	6,216	398	6,614
June	176	111	5,897	366	6,263
July	214	122	6,023	352	6,375
Aug.	188	112	6,137	402	6,539
Sept.	201	135	5,889	372	6,261
Oct.	178	104	6,141	378	6,519
Nov.	199	127	5,906	369	6,275
Dec.	200	124	5,983	366	6,349
Total	1,991	1,235[f]	72,946	4,467	77,413

[a] Includes only oil or gas producers and dry holes.
[b] Production figures based on information furnished by oil companies and pipe-line companies.
[c] Includes Devonian production at Sandoval and Bartelso.
[d] From the U. S. Bureau of Mines.
[e] Includes 22 wells formerly dry holes.
[f] Includes 12 wells formerly dry holes.

wells were drilled during 1944 include Albion Consolidated (Edwards County), Bible Grove (Clay-Effingham Counties), Clay City Consolidated (Clay-Wayne Counties), Mt. Carmel (Wabash County), Noble (Richland-Clay Counties), and Phillipstown Consolidated (White County).

Federal Well-spacing Regulations

A change in the regulations of the Petroleum Administration for War governing well spacing in Illinois pools, which was put into effect in April of 1944,[1] is reflected in a decreased percentage of wildcat completions for the year as compared with 1943. Although the number of wells drilled for oil or gas increased from 1791 in 1943 to 1991 in 1944, the number of wildcat wells decreased from 461 wells to 430.

TABLE 4.—*Wildcat Wells Drilled in Illinois in 1944*

Method of Location	Number of Wells	Number of Producers	Percentage of Wells Successful
Geology	273	44	16.11
Seismograph	70	16	22.85
Geology and seismograph	21	4	19.04
Total scientific	364	64	17.58
Nonscientific	59	6	10.17
Unknown	7	0	0
Total	430	70	16.27

The revised regulations permitted drilling of twice as many lime or deep sand wells per 40 acres as under earlier spacing patterns. The immediate effect was a tendency to drill additional wells in proved areas that had been developed on wider spacing patterns during the preceding two years. With drilling limited by the number of rigs and amount of material available, the amount of wildcatting necessarily decreased. By the end of the year the majority of these additional locations had been drilled.

Economic Data

Posted prices for Illinois crude oil in 1944 remained $1.37 for the central basin fields, Salem area, and Griffin area, and $1.22 per barrel for oil in the old Southeastern Illinois fields. The value of crude oil produced in Illinois during 1944, exclusive of premium payments, amounted to approximately $105,385,760.

The Office of Price Administration's stripper-well premium plan provided that price premiums should be paid, beginning Aug. 1, 1944, for production from pools that had an average production per well per day in December 1943 of less than 9 bbl., in accordance with the following schedule:

[1] Supplementary Order No. 5, as amended Apr. 19, 1944 to Petroleum Administrative Order No. 11, as amended Jan. 1, 1944. (Applicable to petroleum production operations in the Illinois basin.)

Average Production per Well per Day in December 1943	Added Price per Barrel, Cents
From 7 to 9 bbl.	20
From 5 to 7 bbl.	25
Less than 5 bbl.	35

The premium is paid by the Defense Supplies Corporation to the oil purchasers, who add the amount of the premium to the regular price paid to the producers. Federal premiums were granted in a total of 54 pools between Aug. 1 and Dec. 31, 1944.

Total footage of wells drilled for oil or gas in Illinois during 1944 was 5,185,408 ft. Of this amount 3,194,316 ft. was drilled in producing wells. On the basis of an estimated average cost of $3.50 per foot of drilling, the total cost of drilling was about $18,150,000. A total of 1,073,714 ft. was drilled in the 430 wildcats completed during the year. Using the same estimated figure of $3.50 per foot, the cost of wildcat drilling amounted to $3,760,000. The average depth of all wells completed in the state in 1944 was 2604 ft, as compared with 2573 in 1943.

TABLE 5.—*Summary of Drilling and Initial Production in Illinois for* 1944[a]

County	Number of Wells Drilled in 1944			Total Initial Production		Footage Drilled in 1944	
	Total Completions	Total Producing: Oil	Total Producing: Gas	Oil, Bbl.	Gas, Millions Cu. Ft.	Total	Producing Wells
Bond	18	7	0	172	0	28,148	7,900
Clark	22	9	0	67	0	17,738	3,948
Clay	176	135	0	10,635	0	465,805	347,095
Clinton	19	1	0	6	0	29,560	974
Coles	14	10	0	295	0	22,984	17,023
Crawford	5	1	1	5	0.5	9,130	1,800
Cumberland	6	1	0	15	0	7,645	356
Douglas	2	0	0	0	0	4,985	0
Edwards	143	95	0	13,462	0	425,590	272,180
Effingham	38	15	0	897	0	96,120	37,810
Fayette	19	1	0	30	0	38,206	1,557
Ford	1	0	0	0	0	2,237	0
Franklin	50	23	0	1,269	0	130,221	55,179
Gallatin	42	25	0	2,264	0	100,069	54,781
Greene	2	0	0	0	0	2,210	0
Hamilton	111	66	0	5,912	0	361,780	209,397
Hancock	2	0	0	0	0	3,950	0
Henderson	9	0	0	0	0	4,794	0
Jackson	2	0	0	0	0	5,916	0
Jasper	18	5	0	479	0	52,684	14,871
Jefferson	142	88	0	12,101	0	366,695	214,734
Kendall	1	0	0	0	0	2,328	0
Lawrence	57	20	3	526	3.675	110,478	38,294
McDonough	3	0	0	0	0	2,411	0
Macoupin	3	1	0	8	0	3,124	469
Madison	51	38	0	5,251	0	101,318	74,723
Marion	46	26	0	873	0	90,634	42,901
Monroe	2	0	0	0	0	1,418	0
Montgomery	11	3	0	16	0	11,975	1,932
Perry	5	0	0	0	0	8,580	0
Pike	2	0	0	0	0	3,807	0
Randolph	3	0	0	0	0	1,634	0
Richland	111	74	1	23,904	1.771	338,700	226,297
St. Clair	12	4	0	177	0	11,088	2,728
Saline	6	1	0	7	0	12,493	1,520
Schuyler	4	0	0	0	0	2,852	0
Shelby	5	0	0	0	0	8,464	0
Union	1	0	0	0	0	1,949	0
Wabash	201	136	1	12,175	1.00	456,341	307,859
Washington	13	4	0	101	0	19,375	5,442
Wayne	330	242	0	35,235	0	1,042,562	760,442
White	277	186	0	20,453	0	759,581	492,104
Will	1	0	0	0	0	1,958	0
Williamson	4	0	0	0	0	9,041	0
	1,991	1,217	6	146,335	6.946	5,185,408	3,194,316

[a] Does not include input wells, salt-water disposal wells, or old wells worked over.

TABLE 6.—*Fields with Wells Producing from More than One Formation*

Field	County	Total Number of Combination Wells	Number of Wells and Producing Formations[a]
Flora	Clay	3	3AM
Iola	Clay	28	1TA, 2CPBA, 10CBA, 1CA, 1PBA, 11BA 1BReA, 1RM
Kenner	Clay	1	1BA
Sailor Springs Consolidated	Clay	4	3TC, 1GC
Clay City Consolidated	Clay, Wayne	97	1CB, 1CAM, 3CR, 6CM, 1CA, 2AL, 1AR, 1ALM, 8ARM, 44AM, 3LM, 26RM
Albion Consolidated	Edwards	30	2BrBi, 1BrDA, 2BrH, 1BrA, 1BiWTM, 1BiWReA, 1BiWReM, 8BiW, 1BiWRe, 1BiWLM, 2WReA, 1WBA, 1WReAM, 1WReM, 1WReB, 1BA, 1BRe, 1BReA, 1ReA, 1ReAM
Albion East	Edwards	3	1CAM, 1PB, 1LM
Cowling	Edwards	2	2CB
Browns	Edwards	6	1CB, 1CBM, 4CM
Ellery	Edwards	1	1AM
Grayville	Edwards, White	1	1PaC
Louden	Fayette, Effingham	664	253CP, 148CB, 209CPB, 65PB
Benton North	Franklin	2	1PA, 1AL
Sesser	Franklin	1	1RM
Whittington	Franklin	1	1 St. M.
Inman East	Gallatin	16	1DCl, 1ClPa, 3ClT, 1PaW, 1PaWT, 2PaT, 2WT, 1WTC, 2WC, 2TC
Inman West	Gallatin	6	5TC, 1TCM
Omaha	Gallatin	3	3PaT
Blairsville	Hamilton	2	1AM, 1ALM
Dale-Hoodville	Hamilton	99	5TC, 1TA, 1CA, 1PA, 86BA, 2BM, 1ARM, 2AM
Rural Hill	Hamilton	71	1CPAL, 1CAL, 21AL, 1AR, 15ALM, 30AM, 2LR
Boos North	Jasper	6	6RM
Boyd	Jefferson	6	6BA
Coil West	Jefferson	4	1AL, 1ALM, 1LRM, 1LM
Divide West	Jefferson	1	1LM
King	Jefferson	2	1AL, 1ALRM
Mt. Vernon	Jefferson	1	1LM
Roaches	Jefferson	3	3RM
Roaches North	Jefferson	1	1BR
Woodlawn	Jefferson	1	1CB
Salem	Marion	951	580BA, 2BAMS, 5BM, 2BMS, 1RM, 308MS, 3MD, 49DTr, 1SD
Calhoun North	Richland	1	1RM
Noble	Richland, Clay	5	5CM
Parkersburg Consolidated	Richland, Edwards	6	6CM
Dundas Consolidated	Richland, Jasper	16	1CM, 2AM, 13RM
Keensburg Consolidated	Wabash	26	4BiT, 3BiC, 2BiA, 10CB, 1CP, 1CBA, 1CA, 2BA, 2AM
Maud	Wabash	2	2WM
Mt. Carmel	Wabash	34	1PeT, 1PeC, 1JC, 8BiC, 3BiCM, 1PeM, 5TC, 2CB, 9CM, 1LM, 2RM
Patton West	Wabash	1	1CL
Lancaster	Wabash, Lawrence	1	1LM
Irvington	Washington	3	2CB, 1BA
Boyleston Consolidated	Wayne	9	3AM, 5LM, 1RM
Cisne	Wayne	15	4AM, 7ARM, 1LM, 3RM
Goldengate Consolidated	Wayne	13	5AM, 5LR, 2LRM, 1LM
Johnsonville	Wayne	45	1AL, 6ALM, 1ALRM, 30AM, 7LM
Johnsonville North	Wayne	1	1LM
Mt. Erie South	Wayne	2	2AM
Sims	Wayne	13	13AM
Sims North	Wayne	8	4ALM, 4LM
Aden Consolidated	Wayne-Hamilton	17	6ALM, 1AR, 2ARM, 8AM
Burnt Prairie	White	2	2AM
Calvin North	White	1	1PePa
Carmi North	White	1	1CA
Centerville East	White	2	1TL, 1TCM
Concord	White	5	2TM, 3CM
Herald	White	2	1TA, 1CA
Iron	White	4	3TH, 1CB
Maunie North	White	4	1CB, 1PA, 2BA
Maunie South	White	3	1BrC, 2PT
New Harmony	White	193	1PeBA, 1BiCA, 6WCBA, 2WC, 2WB, 2WCBAM, 9WCB, 1WM, 1WBM, 1WCA, 1WT, 1WTC, 1WBA, 1TPB, 1TB, 1TCM, 1TM, 2TC, 1TA, 1TP, 1TPC, 5CP, 7CBM, 13CBAM, 33CB, 1CM, 1CPM, 13CA, 1CPB, 1CPBAM, 2CPA, 10CBA, 14PA, 1PAR, 32PB, 15BA, 1BM, 5AM, 1RM

TABLE 6.—(*Continued*)

Field	County	Total Number of Combination Wells	Number of Wells and Producing Formations[a]
New Haven	White	4	4TCB
Phillipstown Consolidated	White	11	1BiCA, 3ClT, 1PeT, 1CBA, 1CAM, 2BA, 1PaB, 1BRM
Stokes	White	11	2TP, 1TA, 2CP, 3CB, 2CA, 1PA
Roland	White, Gallatin	40	9WB, 2WP, 1WCPA, 1WCP, 1TC, 6CB, 4CA, 2CBA, 1CALM, 3BA, 1BAM, 9WA
Mill Shoals	White, Hamilton Wayne	4	3AL, 1LR
		2,522	

[a] Names of sands are indicated as follows:

Pe, Pennsylvanian	D, Degonia	H, Hardinsburg	A, Aux Vases	St., St. Louis
Br, Bridgeport	Cl, Clore	C, Cypress	L, Levias	S, Salem
Bi, Biehl	W, Waltersburg	P, Paint Creek	R, Rosiclare	D, Devonian
J, Jordan	T, Tar Springs	B, Bethel	M, McClosky	Tr, Trenton
Pa, Palestine	G, Glen Dean	Re, Renault		

PIPE LINES

Construction of pipe lines in Illinois during 1944 was confined to two trunk lines carrying refined products, and to several short spurs serving primarily to connect new pools to pre-existing lines as shown in the detailed statement below.

Crude Oil

Central Pipe Line Co.—2 miles 4-in., Dupo field to S. and D. refinery, Dupo, St. Clair County; 2 miles 2-in., Ewing pool south to loading racks on paved highway, Franklin County.

Kingwood-Breuil Consolidated Pipe Line Co.—1 mile 4-in., Boyd field to Texas Company's 6-in. Woodlawn-Salem line, Jefferson County.

Ohio Oil Co.—2½ miles 14-in., Wood River Station to the Allied Pipe Line Co. dock on the Mississippi River, Madison County.

Sohio Pipe Line Co.—5 miles 2-in., Dahlgren field to Mayberry field, connecting through Texas Company's 4-in. feeder to Texas Hoodville-Johnsonville line, Hamilton and Wayne Counties; 2½ miles 4-in., south part of Albion field to Ohio's Albion station, Edwards County; 2½ miles 4-in., New Haven West field to Sohio's Inman line, Gallatin County; 6 miles 3-in., Calhoun field to Olney, Richland County; 6 miles 4-in., Bogota field to Pure Oil's Dundas-Noble line, Jasper County; 2 miles 4-in., Marine pool to Magnolia 10-in., Madison County.

Superior Oil Co.—3 miles 4-in., Brown's pool to Sohio line in Albion, Edwards County.

The Texas Pipe Line Co.—6 miles 4-in., Roaches North field to Woodlawn station, Jefferson County.

Refined Products

Ohio Oil Co.—8 miles (in Illinois) 8-in., Robinson refinery, Crawford County, to Indianapolis, Ind.

The Texas Pipe Line Co.—34 miles 6-in., Lockport refinery, Cook County, Ill., to E. Chicago, Ind.

REFINERIES

No new refineries were constructed in Illinois during 1944. Total daily refinery capacity was about 300,000 barrels.

TABLE 7.—*Natural Gas Produced in Illinois and Marketed in* 1944

Field	County	Where Marketed	Amount Marketed, M Cu. Ft.
Russellville (gas)	Lawrence	Illinois, Indiana, Kentucky	600,000
Ayers (gas)	Bond	Greenville, Ill.	15,000
Salem	Marion	Salem, Ill.	180,000
Louden	Fayette	Vandalia, St. Elmo, Brownstown, Ill.	545,000
			1,340,000

During 1944, Illinois crude-oil production amounted to 23.4 per cent of the runs to stills for refineries in the Central Refining District (Illinois, Indiana, Kentucky, Michigan, and western Ohio) and the Appalachian Refining District (eastern Ohio, western New York, western Pennsylvania and West Virginia). For December

1944, the runs to stills in these two districts were 25,891,000 bbl. Illinois production amounted to 24.5 per cent.

Stocks of crude petroleum on hand in Illinois on Dec. 31, 1944, were 14,390,000 bbl. as compared with 14,053,000 bbl. on Dec. 31, 1943. Stocks of refined products in the Central and Appalachian refining districts compared with 1943, according to the U. S. Bureau of Mines, are as follows:

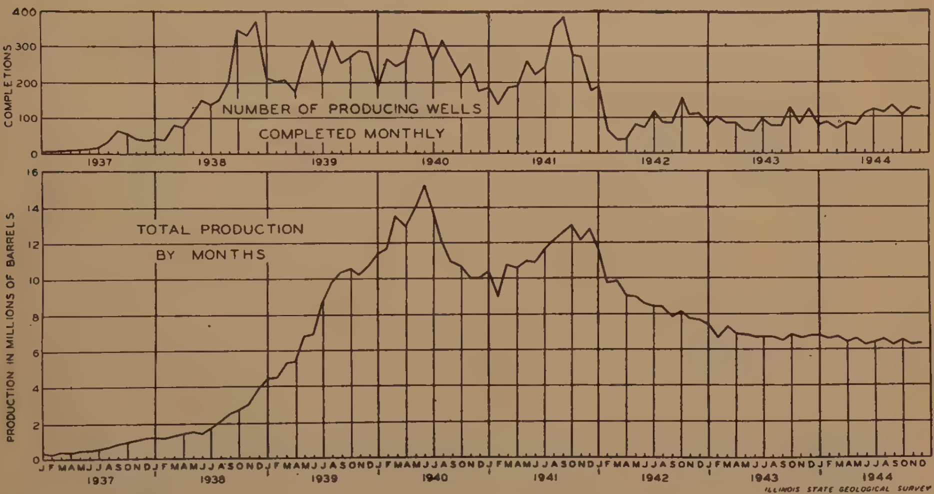

FIG. 1.—NUMBER OF PRODUCING WELLS COMPLETED MONTHLY AND OIL PRODUCTION BY MONTHS IN ILLINOIS, 1937–1944.

PRODUCT	DEC. 31, 1944, BBL.	DEC. 31, 1943, BBL.
Gasoline	21,403,000	18,514,000
Kerosene	2,417,000	2,622,000
Gas oil and distillate fuel	6,616,000	6,947,000
Residual fuel oil	3,293,000	3,307,000

NATURAL GAS, NATURAL GASOLINE AND LIQUEFIED PETROLEUM GASES

The total gas production of all Illinois oil and gas fields in 1944 is estimated at 45 to 60 billion cubic feet. Of this amount a little over one per cent is produced from gas fields or from gas wells in oil fields, and somewhat over 2 per cent is sold to industrial or domestic users. Table 7 indicates the source and disposal of this commercially marketed gas.

Approximately 22 billion cubic feet of gas from oil wells in the Benton, Dale-Hoodville, Louden, New Harmony, Salem, and Southeastern fields was utilized in 1944 in natural gasoline plants to produce 64,500,000 gal. of natural gasoline and 136,000,000 gal. of liquefied petroleum gases. Of 15 to 17 billion cubic feet of residue gas from these operations, approximately half was returned to the producing formations, one third was utilized as fuel in the plants or on leases, 725 million cubic feet was marketed commercially, and somewhat over two billion cubic feet was burned in flares. Well over half of the unmetered gas produced in fields without pipe-line connections or natural gasoline plants is used as lease fuel. It seems likely that considerably less than one sixth of all the gas produced in Illinois in 1944 was allowed to escape or was burned in flares without being utilized.

SECONDARY RECOVERY

In the Patoka pool the break in the rate of decline and the subsequent increase in production from 298,000 bbl. in 1943 to 630,000 bbl. in 1944 can be attributed primarily to the water-flooding project

begun by the Felmont Corporation in 1943. During 1944, injection of 1,377,000 bbl. of water to the Bethel sand through 30 injection wells resulted in an estimated increased production of 470,000 bbl. of oil.

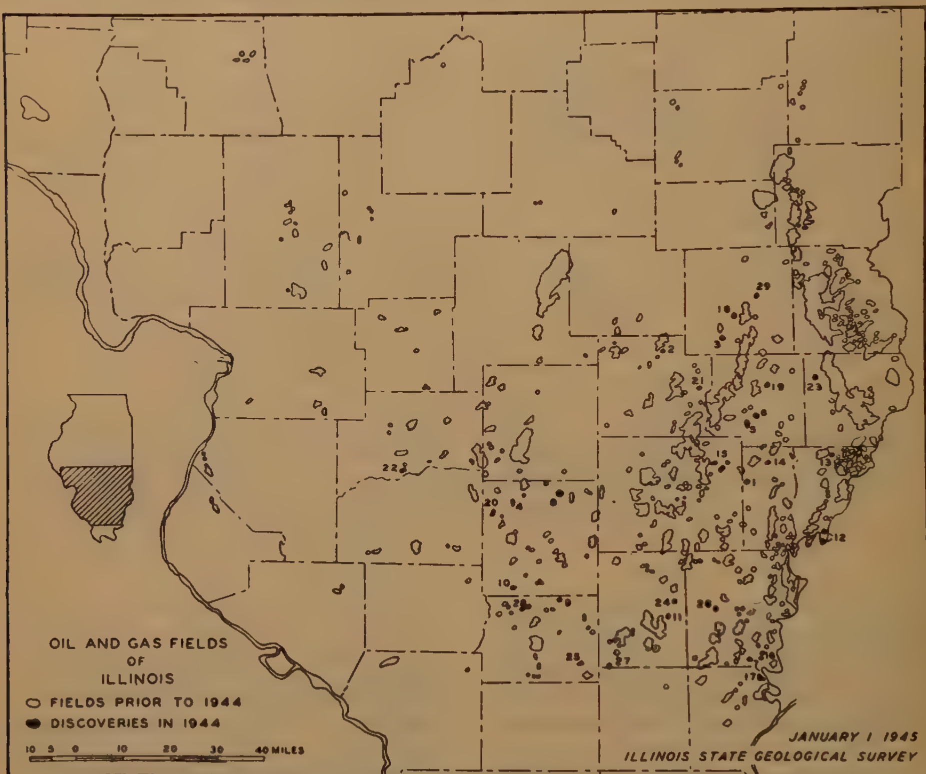

FIG. 2.—INDEX MAP OF NEW OIL FIELDS DISCOVERED IN ILLINOIS IN 1944.
Older fields are also shown except Colmar-Plymouth, in McDonough and Hancock Counties, which is outside of the area of the map.

1. Bennington South
2. Bible Grove East
3. Bogota South
4. Boyd
5. Calhoun
6. Calhoun North
7. Concord South
8. Divide West
9. Ewing
10. Fitzgerrell
11. Hoodville East
12. Keensburg South
13. Lancaster East
14. Maplegrove East
15. Mt. Erie North
16. New Haven North
17. New Haven West
18. Newton
19. Olney East
20. Roaches North
21. Sailor Springs East
22. Santa Fe
23. Sumner
24. Thackeray
25. Thompsonville North
26. Trumbull
27. West End
28. Whittington West (discovered in 1943; named 2/3/44)
29. Willow Hill

In the Clay City Consolidated pool the Pure Oil Co. injected 1,413,000 bbl. of water into the McClosky through a number of wells, varying from three at the beginning of the year to eight and finally seven at the end of the year. The result was an increase of 85,500 bbl. of oil during the year. The cumulative increased production in this operation by the end of the year was estimated at 146,000 bbl. The same company in 1944 began a flood through eight McClosky input wells in Dundas Consolidated pool, injecting 1,489,000

bbl. of water, with a resultant production increase of 83,800 bbl. Injection of 59,000 bbl., begun in 1944 through one well in the townsite area of Noble Consolidated pool, had resulted in an increased production of 369 bbl. by the end of the year. It is noteworthy that all of these flooding projects by the Pure Oil Co. are in a limestone rather than a sandstone producing zone.

The Forest Oil Corporation's flooding operation in the Westfield pool, Clark County, was abandoned July 1, 1944, after injection of 573,000 bbl. of water had failed to induce commercial production. This company's second flood, in the Siggins pool in Cumberland County, begun in 1942, was continued and had a cumulative production of 31,000 bbl. at the end of 1944, all from flowing wells, after the injection of 923,000 bbl. of water. Their third flood, on a lease adjoining the second, was begun in 1944 with a wider spacing pattern and with the producing wells pumped rather than flowed. Although this work was barely started in 1944, it had produced 35,000 bbl. of oil by Dec. 31, with injection of 305,000 bbl. of water through three injection wells. These projects are operating in shallow Pennsylvanian sands.

Minor water-flooding projects and accidental flooding due to faulty plugging of abandoned wells have arrested decline curves or increased production on certain leases in a number of pools, including Allendale (Wabash and Lawrence Counties); Keensburg Consolidated (Wabash County); Lawrence (Lawrence County); the Crawford County division; and in Centralia (Marion and Clinton Counties).

The extensive long-term gas-recycling and pressure-maintenance projects in Salem, Louden, and New Harmony Consolidated remain successful in partially arresting the rate of production decline. The total increased production, although very large, is from the nature of this type of operation difficult to estimate. The Louden project, begun early in the history of the pool, has maintained pressure so successfully that 161 wells are still flowing, after seven years. In this pool approximately five million cubic feet of gas is injected daily through 98 input wells. As a result of the success of these projects, a number of similar operations have been started during 1944 in Illinois basin pools. The pools involved in these newer operations include Dale-Hoodville, Rural Hill, Mt. Carmel, Walpole, and Benton.

Repressuring projects in several of the older fields, using injection of air, gas, or air and gas simultaneously, were begun at various times in the history of the field and estimates of increased production are available. In a project begun in 1935 in the Colmar-Plymouth field, injection of 312 million cubic feet of air through 65 wells in 1944 resulted in an increased production of 57,000 bbl. The cumulative increase per acre in this project over a 16-yr. period has amounted to approximately 500 bbl. Summary of a number of projects in Crawford County indicates that approximately 1,300,000,000 cu. ft. of air and gas was injected in 1944 through 280 wells, 90 of which were converted or drilled during the year. Considerable extensions to the areas being repressured in the Southeastern field are being planned for the near future.

Outlook for 1945

Drilling in Illinois is expected to continue in 1945 at nearly the same rate as in 1944, with probably some increase in wildcat drilling. During 1945 and 1946 a considerable number of 10-yr. leases will expire unless renewed or unless production is discovered on them. Continued demand for oil in this region for both military and civilian uses will encourage production by all possible methods, including both attempts to discover new pools and expansion of secondary recovery.

Increased costs of drilling, and shortage of equipment and manpower are factors

that limit the rate of drilling development. Since May 21, 1941, the price of crude oil has been frozen, but since that time drilling and production costs have risen sharply. The price premium for stripper well production is of some help but it does not meet the situation.

Geological data from thousands of wells in Illinois reveal a different picture of the oil reservoirs than was available two or three years ago. Production is from many small lenticular reservoirs, and many producing structures are so small as to be near the limits of error of the reflection seismograph. This means that, aside from the possibility of pre-Mississippian production in Illinois, wildcat drilling for Mississippian and Pennsylvanian sands will continue in Illinois for many years, and that many more pools, extensions, and new pays remain to be discovered and developed. This and the expansion of secondary recovery of oil promise well for the future of the oil industry in this region.

Acknowledgments

The writers are indebted to many oil and gas companies, pipe-line companies, and refining companies for data used in this report. The following members of the Survey staff assisted in preparing the report: Carl A. Bays, Frederick Squires, David H. Swann, Wayne F. Meents, James S. Yolton, and Margaret Sands.

Oil and Gas Activity in Indiana in 1944

By Otis W. Freeman*

Production of oil in Indiana during 1944 is estimated at approximately 4,950,000 bbl., a decline of 6 per cent from the preceding year. Shortage of labor and material, together with governmental regulations resulting from the war, largely account for the drop in output and limited new developments. Three new pools were discovered in the state during 1944. Two of these, New Harmony, South, and Hovey, West, are in Posey County. Six wells in the New Harmony, South, field produced 66,422 bbl. of oil last year. A third field, Cato, in Pike County, did not market the oil from its discovery well during 1944. Several wells discovered oil in the Henderson field of Jay County along the Ohio state line. An important south extension of the St. Thomas field in Knox County was discovered during the year. Active drilling took place in the Inman, East, and Upton fields, Posey County, both discovered in 1943. Twenty-two wells in Inman, East, produced 151,191 bbl. in 1944 and 12 in Upton produced 107,052 bbl. Owensville, and especially Owensville, North, in Gibson County, made large gains in production as a result of active drilling. The Dodds Bridge field in Sullivan County continued good production from deep sands reached in 1942.

The Griffin continued to be the largest producer among the oil pools of Indiana, accounting for 2,004,180 bbl., over 40 per cent of the state's output. The next largest producing fields are Mt. Vernon and New Harmony, both in Posey County.

The largest gas well brought in during 1944 was in the Rockport field, Spencer County, and had an initial output of 2,680,000 cu. ft. per day. The most productive gas fields in Indiana are Rockport, Spencer County, Greensburg, Decatur County, and Unionville, Monroe County. Total production in the state is hard to estimate, as considerable gas is consumed in farm homes and for other local uses, and never is reported, but was near 1500 million cubic feet. Some oil from the Trenton field is also used locally and is unreported from pipe-line runs.

A total of 606,145 ft. of new hole was drilled in Indiana in 1944. Most of the completions were in Posey and Gibson counties, although wells were drilled in 36 different counties. During the year 331 wells were completed. Of these, 145 found oil in commercial quantities and 28 were gas wells. The initial production of the 145 oil wells was 11,908 bbl. per day. Settled production would be less, of course. The largest wells reported during the year were two on the J. W. Mann farm, in the Mt. Vernon field, with a flush flow of 500 to 800 bbl. each.

Six pools, all small "one well" affairs, were abandoned in 1944; i.e., Fleenor and Patoka in Gibson County, Grafton and Rapture in Posey County, Vaughn in Vanderburgh County and Millersburgh, Warrick County.

Manuscript received at the office of the Institute May 22, 1945.

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TABLE 1.—*Oil and Gas Production in Indiana*

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
1	Cannelburg, *Daviess*[2]	1925	690	144,739	24,039	*x*	0	84	4	0
2	Glendale-Hudsonville, *Daviess*	1929	1,200	0	0	*x*	*x*	67	1	0
3	North Glendale, *Daviess*	1941	180	*x*	*x*	*x*	*x*	14	0	4
4	Veale, *Daviess*	1926	420	*x*	*x*	0	0	82	1	0
5	Greensburg, *Decatur*	1893	37,010	0	0	5,000?	200?	410	9	0
6	Columbia, *Gibson*	1941	90	5,716	1,129	0	0	5	0	0
7	Fleenor, *Gibson*[1]	1940	20	4,500	0	0	0	1	0	1
8	Francisco, *Gibson*	1929	730	216,401	15,967	1,260?	5?	46	0	0
9	Hazelton, *Gibson*	1941	1,160	451,888	120,403	*x*	*x*	31	4	2
10	Johnson, *Gibson*	1941	20	8,261	1,585	0	0	2	0	1
11	Kirksville, *Gibson*	1941	420	188,062	72,405	*x*	*x*	38	9	5
12	Mt. Carmel, *Gibson*[2]	1941	30	23,123	12,305	0	0	3	0	2
13	North Owensville, *Gibson*	1943	150	273,497	234,368	0	0	33	23	0
14	Owensville, *Gibson*	1940	120	18,540	13,640	0	0	5	3	1
15	Patoka, *Gibson*[1]	1941	40	4,857	0	0	0	4	2	2
16	Somerville, *Gibson*	1942	40	8,622	2,986	0	0	4	0	1
17	West Princeton, *Gibson*	1903	1,870	*x*	*x*	*x*	0	151	0	*x*
18	Griffin, *Gibson, Posey*	1938	4,070	17,426,870	2,004,180	0	0	454	16	4
19	Mumford Hill, *Gibson, Posey*	1939	350	118,668	20,796	0	0	13	0	0
20	Loconia, *Harrison*	1910	6,605	0	0	*x*	*x*	130	0	*x*
21	Trenton, *Jay* and 13 other counties	1886	778,080	104,800,000?	30,000?	800,000?	10?	26,634	10	*x*
22	Monroe City, *Knox*	1922	400	*x*	*x*	0	0	15	0	0
23	Mt. Carmel, *Knox*[2]	1941	220	16,248	3,670	*x*	0	7	5	2
24	Oaktown, *Knox*	1930	1,080	*x*	*x*	25,000?	400?	82	0	0
25	St. Francisville, *Knox*[2]	1942	40	15,791	3,183	0	0	3	0	0
26	St. Thomas, *Knox*	1940	480	79,027	8,975	0	0	9	3	2
27	Loogootee, *Martin, Daviess*	1900	2,200	*x*	*x*	*x*	*x*	60	2	1
28	Unionville, *Monroe*	1929	1,400	0	0	600?	200?	18	0	0
29	Bristow, *Perry*	1929	270	*x*	10,926	0	0	46	1	1
30	Troy-Tell City, *Perry, Spencer*	1928	940	*x*	1,986	*x*	*x*	85	2	2
31	Alford, *Pike*[4]	1919	1,090	*x*	*x*	*x*	*x*	97	0	*x*
32	Iva, *Pike*	1936	160	0	0	*x*	*x*	6	1	1
33	Spurgeon, *Pike*	1941	20	34,077	8,057	0	0	3	1	1
34	Oakland City, *Pike, Gibson*	1907	3,110	*x*	*x*	*x*	0	63	1	1
35	Oatsville-Wheeling, *Pike, Gibson*	1919	1,950	*x*	27,800	0	0	269	10	*x*
36	Tri County, *Pike, Gibson*	1925	370	*x*	*x*	*x*	0	74	0	0
37	Union-Bowman, *Pike, Gibson*	1916	5,180	*x*	*x*	*x*	*x*	416	8	1

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Abandoned. [2] Extension from Illinois. [3] Includes Veale. [4] Includes Rush gas field.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	0	27	0	x	x	x	x	Chester, MisU	S	P	630	10	A	Chester	895
2	0	0	15	x	x	x	x	Barker, MisU	S	P	650	10	T	St. Louis	1,575
3	0	0	6	124.4	x	x	x	Cypress, MisU	S	P	678	x	D	MisL	1,018
4	0	31	0	x	x	x	x	McClosky, MisL	Ls	P	1,161	10	A	Devonian	2,618
5	0	0	164	275	x	x	x	Trenton, Ord	Ls	P	886	10	A	Pre-Cambrian	3,055
6	0	0	0	x	x	36	x	Cypress, MisU	S	P	1,190	6	D	MisU	1,536
7	0	0	0	0	0	x	x	McClosky, MisL	Ls	P	2,673	8	D	MisL	2,714
8	0	8	1	690	x	33	x	Brown, MisU McClosky, MisL	S Ls	P P	1,340 1,600	25	A	Ordovician	4,006
9	0	27	0	x	x	39.5	x	McClosky, MisL Salem, MisL Osage, MisL	Ls Ls Ls	P P P	1,735 2,035 2,402	5 5 10	A	Silurian	3,150
10	0	1	0	x	x	32	x	Pennsylvanian, Pen	S	P	1,095	6	D	MisL	2,802
11	0	23	3	x	x	38	x	Hardinsburg, MisU McClosky, MisL	S Ls	P P	1,333 1,787	22 5	A	MisL	1,956
12	0	1	0	x	x	38	x	Cypress, MisU	S	P	1,976	12	A	MisL	2,355
13	0	30	0	x	x	35.6	x	Cypress, MisU Bethel, MisU McClosky, MisL	S S Ls	P P P	1,575 2,129 2,440	12 3 8	A	MisL	2,494
14	0	3	0	x	x	39.5	x	St. Louis, MisL	Ls	P	2,690	7	D	MisL	2,703
15	0	0	0	x	x	40.5	x	McClosky, MisL	Ls	P	2,250	x	D	Ste. Genevieve	2,300
16	0	3	0	x	x	x	x	Tar Springs	S	P	1,117	20	D	MisU	2,266
17	0	x	0	x	x	x	x	West Princeton, PenL	x	P	890	x	A	St. Louis	3,905
18	0	423	0	x	x	38	x	Pennsylvania, Pen Waltersburg, MisU Tar Springs, MisU Cypress, MisU Aux Vases, MisU McClosky, MisL	S S S S S Ls	P P P P P P	1,250 2,050 2,125 2,500 2,750 2,850	15 20 25 20 8	A	Osage	3,526
19	0	7	0	x	x	36–38	x	Cypress, MisU McClosky, MisL	S Ls	P P	2,458 2,917	17 20	D	MisL	3,047
20	0	0	33	175	x	x	x	New Albany, Dev	Sh	Fis	690	20	M	Trenton	1,770
21	0	200?	60?	325	x	36	x	Trenton, Ord	L, D	P, Fis	900	10	A	Pre-Cambrian	3,996
22	0	7	0	x	x	x	x	Mansfield, Pen Cypress, MisU Mooretown, MisU Paoli, MisU	S S S Ls	P P P P	880 1,235 1,465 1,520	10 15 10 x	M	Salem	1,935
23	0	4	0	x	x	x	x	Cypress, MisU McClosky, MisL	S Ls	P P	1,981 2,292	11 3	A	Ste. Genevieve	2,349
24	0	5	26	280	x	35	x	Stauton, PenL	S	P	580 790	15	ML	Ste. Genevieve	1,592
25	0	3	0	x	x	39.5	x	Bethel, MisL	S	P	1,737	13	A	MisL	1,936
26	0	6	0	x	x	39.5	x	McClosky, MisL	Ls	P	1,871	8	D	Ste. Genevieve	2,050
27		10?	x	x	x	x	x	Mooretown, MisU	S	P	532	10	A	Trenton	3,025
28	0	0	13	250	x	x	x	Coniferous, DevM	Ls	P	800	40	AF	Trenton	2,102
29	0	4	0	x	x	33	x	Tar Springs, MisU Cypress, MisU Elwren, MisU	S S S	P P P	280 465 503	7 10 9	ML	Trenton	3,255
30	0	27	2	x	x	34	x	Sample Cypress Mooretown } MisU	S	P	468 747 805	x	NMF	MisL	1,708
31	0	7	20	x	x	38	x	Oakland City, MisU Brown Sands, MisU	S S	P P	630 1,080 1,130	10 10	A	St. Louis	1,413
32	0	0	5	x	x	x	x	Hardinsburg, MisU	S	P	750	8	D	MisL	1,174
33	0	2	0	x	x	34.5	x	Cypress, MisU	S	P	1,143	8	D	MisU	1,185
34	0	34	0	x	x	28	x	Oakland City, MisU Brown, MisU	S S	P P	1,085 1,107	10 10	A	MisL	1,675
35	0	200	0	x	x	32	x	Sample, MisU Cypress, MisU Mooretown, MisU Paoli, MisU	S S S S	P P P P	1,250 1,270 1,340 1,725	x x x x	A	Harrodsburg	2,050
36	0	13	0	x	x	34	x	Brazil, PenL Oakland City, MisU	S S	P P	315 1,317	10 10	A	Ste. Genevieve	1,998
37	0	270	0	x	x	35	x	Cypress, MisU Mooretown, MisU Paoli, MisU Hardinsburg, MisU McCloskey, MisL	S S Ls S Ls	P P P P P	945 1,233 1,250 1,290 1,778	5 x 7 10	A	Salem	2,205

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Millions Cu. Ft.[e]: To End of 1944	Gas Production: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
38	Bufkin, *Posey*	1940	150	155,890	26,743	0	0	10	0	0
39	Caborn, *Posey*	1940	730	741,785	170,995	*x*	*x*	46	5	3
40	Caborn, West, *Posey*	1941	100	42,122	7,985	0	0	7	0	0
41	College, *Posey*	1940	100	107,220	14,374	0	0	7	0	0
42	Grafton, *Posey*[1]	1942	20	694	0	0	0	1	0	1
43	Half Moon, *Posey*	1942	20	8,853	2,354	0	0	1	0	0
44	Hovey Lake, *Posey*	1942	20	5,657	1,868	0	0	1	0	0
45	Hovey, West, *Posey*	1944	40	1,493	1,493	0	0	1	0	0
46	Inman, East, *Posey*	1943	200	153,437	151,191	0	0	24	23	0
47	Lamott, *Posey*	1941	40	46,640	10,844	0	0	4	0	0
48	Mt. Vernon, *Posey*	1941	810	1,590,876	378,619	0	0	29	6	2
49	New Harmony, *Posey*	1939	430	2,600,004	395,707	0	0	33	3	2
50	New Harmony, South, *Posey*	1944	200	66,422	66,422	0	0	14	14	8
51	New Haven, *Posey*[2]	1942	20	20,283	5,924	0	0	2	1	1
52	Point, *Posey*	1942	20	31,179	3,979	0	0	1	0	0
53	Prairie, *Posey*	1942	120	11,417	1,434	0	0	5	4	0
54	Rapture, *Posey*[1]	1941	20	595	0	0	0	1	0	1
55	Ridge, *Posey*	1942	20	3,439	880	0	0	1	0	0
56	Rogers, *Posey*	1943	80	25,701	15,373	0	0	3	1	0
57	St. Wendells, *Posey*	1934	240	*x*	*x*	0	0	28	0	0
58	Stooker, *Posey*	1942	40	33,668	8,364	0	0	2	0	0
59	Upton, *Posey*	1943	600	107,658	107,052	0	0	13	12	0
60	Welborn, *Posey*	1941	20	18,497	4,899	0	0	3	1	1
61	Heusler, *Posey, Vanderburgh*	1938	*x*	1,298,248	144,502	0	0	55	4	2
62	Enterprise, *Spencer*	1939	170	*x*	7,018	0	0	14	3	2
63	Eureka, *Spencer*	1942	10	3,439	286	0	0	1	0	0
64	Grandview, *Spencer*	1940	100	*x*	8,794	0	0	10	3	2
65	Hatfield, *Spencer*	1941	130	*x*	29,500	0	0	15	1	1
66	Rock Hill, *Spencer*	1929	310	*x*	*x*	0	0	25	1	1
67	Rockport, *Spencer*	1939	*x*	*x*	30,760	*x*	*x*	72	6	0
68	Richland, *Spencer*	1943	40	*x*	*x*	0	0	2	1	1
69	Gentryville, *Spencer, Warrick*	*x*	260	*x*	*x*	0	0	13	0	0
70	Dodds Bridge, *Sullivan*	1942	400	277,587	94,466	0	0	107	0	*x*
71	Marts, *Sullivan*	1932	200	*x*	0	*x*	*x*	16	0	0
72	Shelburn-Sullivan, *Sullivan*	1911	5,780	3,802,955	83,191	*x*	*x*	1,000	0	*x*
73	Vanderburgh, *Vanderburgh*	1931	600	*x*	*x*	0	0	95	0	*x*
74	Vaughn, *Vanderburgh*[1]	1941	120	1,214	0	0	0	1	0	0
75	Vienna, *Vanderburgh*[4]	1933	*x*	*x*	*x*	0	0	103	0	*x*
76	Vernon Heights, *Vanderburgh*	1941	300	162,334	54,962	0	0	26	10	0
77	Prairie Creek, *Vigo*	1937	460	652,187	59,293	0	0	24	0	2
78	Riley, *Vigo*	1906	310	*x*	*x*	0	0	33	0	*x*
79	Siosi, *Vigo, Sullivan*	1926	880	3,346,779	115,378	0	0	86	0	*x*
80	Millersburg, *Warrick*[1]	1941	20	*x*	*x*	0	0	1	0	0

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
38	0	10	0	x	x	32–34	x	Cennsylvanian, Pen Pypress, MisU	S S	P P	634 1,130 2,382	x 23 18	A	St. Louis	2,863
39	0	35	x	x	x	27–34	x	Pennsylvanian, Pen Waltersburg, MisU Tar Springs, MisU Cypress, MisU	S S S S	P P P P	1,095 1,880 1,990 2,367	12 x 10 x	A	Salem	2,740
40	0	5	0	x	x	34	x	Cypress, MisU	S	P	2,497	6	A	MisL	2,670
41	0	5	0	x	x	38.5	x	Aux Vases, MisU McClosky, MisL	S Ls	P P	2,505 2,618	10 4	D	St. Louis	2,729
42	0	0	0	x	x	36	x	Tar Springs, MisU	S	P	2,139	7	D	MisL	3,010
43	0	1	0	x	x	x	x	Aux Vases, MisU	S	P	2,609	11	D	MisL	2,653
44	0	1	0	x	x	x	x	Pennsylvanian, Pen	S	P	1,095	10	D	Pen	1,135
45	0	1	0	x	x	x	x	McClosky, MisL	Ls	P	2,208	10	D	MisL	2,850
46	0	22	0	x	x	39	x	Tar Springs, MisU Aux Vases, MisU	S S	P P	2,039 2,641	10 12	D	McClosky	2,851
47	0	3	0	x	x	35.5	x	Tar Springs, MisU	S	P	1,945	6	D	Ste. Genevieve	2,812
48	0	20	0	x	x	35.5	x	Waltersburg, MisU Cypress, MisU	S S	P P	2,000 2,425	18 23	A	St. Louis	3,000
49	0	31	0	x	x	36.5	x	Waltersburg, MisU Tar Springs, MisU Cypress, MisU McClosky, MisL	S S S Ls	P P P P	2,172 2,295 2,610 2,968	35 10 11 4	A	St. Louis	3,028
50	0	6	0	x	x	39.3	x	Hardinsburg, MisU	S	P	2,444	25	D	Ste. Genevieve	3,150
51	0	1	0	x	x	39	x	Cypress, MisU	S	P	2,457	7	A	MisL	2,925
52	0	1	0	x	x	38	x	McClosky, MisL	Ls	P	2,750	4	D	MisL	2,908
53	0	5	0	x	x	39	x	Tar Springs, MisU McClosky, MisL	S Ls	P P	2,130 2,839	8 12	D	MisL	2,968
54	0	0	0	x	x	x	x	McClosky, MisL	Ls	P	2,972	6	D	MisL	3,109
55	0	1	0	x	x	35.5	x	McClosky, MisL	Ls	P	2,737	5	D	MisL	2,742
56	0	3	0	x	x	36	x	Clore, MisU Waltersburg, MisU	S S	P P	1,887 2,195	3 10	D	MisU	2,963
57	0	26	0	x	x	x	x	Mansfield, PenL	S	P	1,007	30	ML	Chester	1,920
58	0	2	0	x	x	32–36.5	x	McClosky, MisL	Ls	P	2,612	7	D	MisL	2,621
59	0	12	0	x	x	38.5	x	Tar Springs, MisU Aux Vases, MisU St. Louis, MisU	S S Ls	P P P	2,143 2,740 2,975	7 10 7	D	St. Louis	2,982
60	0	1	0	x	x	36	x	Cypress, MisU	S	P	2,476	30	D	St. Louis	2,995
61	0	41	0	x	x	27–35	x	Waltersburg, MisU Tar Springs, MisU	S S	P P	1,750 1,855	25 25	AF	Ste. Genevieve	2,643
62	0	9	0	x	x	32–36	x	Palestine, MisU Cypress, MisU McClosky, MisL	S S Ls	P P P	915 1,404 1,571	10 8 8	D	MisL	1,745
63	0	1	0	x	x	38	x	McClosky, MisL	Ls	P	1,652	2	D	MisL	1,674
64	0	8	0	x	x	36	x	Aux Vases, MisU	S	P	982	10	D	MisU	1,077
65	0	12	0	x	x	34	x	Waltersburg, MisU	S	P	1,029	15	A	St. Louis	1,783
66	0	21	0	x	x	34	x	Sample, MisU	S	P	1,310	10	MC	Ste. Genevieve	1,506
67	0	24	39	x	x	33.5	x	Pennsylvanian, PenL Palestine, MisU	S S	P P	885 950	10 10	A	St. Louis	1,707
68	0	1	0	x	x	x	x	McClosky, MisL	Ls	P	1,540	10	D	MisL	1,548
69	0	x	0	x	x	x	x	Tar Springs, MisU	S	P	725 634	33	D	MisL	1,241
70	0	6	0	x	x	46	x	Pennsylvanian, Pen Devonian, Dev	S Ls	P P	700 2,337	x 13	A	Devonian	2,386
71	0	0	9	x	x	x	x	Pennsylvanian, Pen	S	P	313 298	9	D	Pennsylvanian	628
72	0	250?	18?	110	x	35	x	Pennsylvanian, Pen Harrodsburg, MisL	S Ls	P P	730–800 1,400	x x	AN	Silurian	2,875
73	0	50?	0	x	x	30.5	x	Mansfield, PenL Silurian, Sil	S Ls	P P	900 2,270	x x	ML	Ste. Genevieve	2,435
74	0	0	0	x	x	34	x	Waltersburg, MisU	S	P	1,647	8	D	MisL	2,562
75	0	34	1	x	x	29	x	Providence, Pen Mansfield, PenL	S S	P P	468 1,007	16 30	NL	Chester	1,920
76	0	22	0	x	x	34 39	x	Waltersburg, MisU McClosky, MisL	S Ls	P P	1,770 2,502	16 15	A	MisL	2,653
77	0	13	0	x	x	37	x	Niagaran, Dev, Sil	Ls	P	2,074	x	D	Silurian	2,232
78	0	1	0	x	x	50	x	Niagaran, Dev	Ls	P	1,605	x	A	Niagaran	1,802
79	0	37	0	x	x	39	x	Niagaran, Dev, Sil	Ls	P	2,100	x	D	Trenton	3,554
80	0	0	0	x	x	x	x	McClosky, MisL	Ls	P	1,887	3	D	MisL	1,956

TABLE 2.—*Summary of Drilling Operations in Indiana*

Important Wildcats Drilled in 1944

Line Number	County	Location: Sec.	Location: Twp.	Location: Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Remarks
1	Adams	35	25N	13E	2,510	Silurian	Cambrian	R. O. McKee				Dry
2	Carroll	23	25N	3W	610	Devonian	Silurian	Perfect Oil Co.				Dry
3	Daviess	22	3N	6W	776	Pen	Lower Chester	Cledus Slabaugh				Dry
4	Dubois	24	1N	6W	891	Pen	Lower Chester	E. S. Holmans				Dry
5	Dubois	35	3S	5W	3,803	Pen	Trenton	The Texas Co.				Dry
6	Gibson	25	1S	12W	2,400	Pen	Ste. Genevieve	White Eagle Oil Co.				Dry
7	Gibson	32	2S	11W	2,452	Pen	Ste. Genevieve	L. J. Loyd				Dry
8	Gibson	33	3S	9W	2,085	Pen	Ste. Genevieve	The Texas Co.				Dry
9	Gibson	25	3S	12W	2,527	Pen	Ste. Genevieve	J. F. Fleming	150		None	Oil Well
10	Gibson	11	3S	12W	1,202	Pen	Pennsylvanian	Carl Miles				Dry
11	Gibson	25	3S	12W	2,521	Pen	Ste. Genevieve	Savage & Fleming	220		None	Oil well
12	Gibson	26	3S	12W	2,697	Pen	Ste. Genevieve	H. H. Weinert				Dry
13	Gibson	27	3S	12W	2,729	Pen	Ste. Genevieve	Cherry, Kidd & O'Neal				Dry
14	Grant	8	23N	8E	1,044	Silurian	Trenton	Jas. C. Reynolds				
15	Greene	21	7N	6W	1,900	Pen	Devonian	Ky. Nat'l. Gas Corp.				Dry
16	Greene	23	7N	4W	1,504	Mis	Devonian	Shell Oil Co.		350M	(⅓ million)	Gas well
17	Greene	15	7N	6W	1,720	Pen	Devonian	Ky. Nat'l. Gas Corp.				Dry
18	Huntington	21	27N	9E	1,048	Silurian	Trenton	The Texas Co.				Dry
19	Jackson	16	6N	4E	425	Lower Mis	Devonian	George Clore				Dry
20	Jay	22	23N	15E	1,181	Silurian	Trenton	L. R. Freel	15			Oil well
21	Knox	35	1N	12W	1,419	Pen	Upper Chester	T. W. George	25			Oil well
22	Knox	Sur. 16	3N	10W	1,951	Pen	Ste. Genevieve	Carl Robinson				Dry
23	Knox	Don. 29	3N	9W	1,742	Pen	Lower Chester	Robinson-Puckett, Inc.				Dry
24	Knox	36	2N	11W		Pen	Ste. Genevieve	Wm. P. Muller	22			Oil
25	La Porte	19	37N	2W	460	Mis	Devonian		5			Oil
26	Martin	25	3N	5W	593	Pen	Ste. Genevieve	M. W. Brewer				Dry
27	Orange	19	3N	2W	1,517	Mis (Chester)	Silurian	Bedford Dev. Co.				Dry
28	Owen	2	9N	5W	2,515	Mis (Chester)	Trenton	The Texas Co.				Dry
29	Owen	3	9N	5W	2,595	Pen (Lower)	Trenton	The Texas Co.				Dry
30	Parke	15	15N	8W	1,700	Pennsylvanian	Silurian	Craig & Phillips				Dry
31	Parke	16	16N	8W	1,504	Pennsylvanian	Devonian	Clark C. Nye				Dry
32	Perry	17	5S	2W	719	Mississippian	Ste. Genevieve	Lona Larkin				Dry
33	Perry	31	5S	2W	692	Mississippian	Ste. Genevieve	Lona Larkin				Dry
34	Perry	25	4S	3W	3,255	Mis (Chester)	Trenton	Central Pipe Line				Dry
35	Pike	8	1S	7W	1,139	Pennsylvanian	Chester (Mis)	H. C. Detrick	18			Oil
36	Pike	9	3S	6W	1,377	Pennsylvanian	Ste. Genevieve	Kigo Drlg. Co.				Dry
37	Porter	9	36N	5W	1,115	Devonian	Trenton	Tri-State Syndicate				Dry
38	Posey	7	4S	13W	2,975	Pennsylvanian	Ste. Genevieve	C. E. Skiles				Dry
39	Posey	31	4S	13W	2,984	Pennsylvanian	Ste. Genevieve	Sun Oil Co.				Dry
40	Posey	7	4S	13W	3,032	Pennsylvanian	Ste. Genevieve	H. L. Cokes				Dry
41	Posey	4	5S	12W	2,769	Pennsylvanian	Ste. Genevieve	Farm Bureau Oil Co., Inc.				Dry
42	Posey	27	5S	12W	2,735	Pennsylvanian	Ste. Genevieve	Ryan Oil Co.				Dry
43	Posey	32	5S	13W	3,049	Pennsylvanian	Ste. Genevieve	B. M. Heath				Dry
44	Posey	2	6S	12W	2,738	Pennsylvanian	Ste. Genevieve	Carter Oil Co.				Dry
45	Posey	14	6S	12W	2,695	Pennsylvanian	Ste. Genevieve	M. P. Evans				Dry
46	Posey	27	6S	14W	2,981	Pennsylvanian	Ste. Genevieve	Sun Oil Co.				Dry
47	Posey	25	7S	15W	2,850	Pennsylvanian	Ste. Genevieve	Rogers Cartage Co.	55			Oil
48	Posey	36	8S	14W	2,756	Pennsylvanian	Lower Chester	Hodges & Walter				Dry
49	Posey	32	6S	14W	2,784	Pennsylvanian	Lower Chester	Carter Oil Co.	85			Oil
50	Posey	25	7S	15W	2,850	Pennsylvanian	McClosky	C. E. Brehm				Dry
51	Posey	14	5S	14W		Pennsylvanian	Mid Chester	Sells Petr. Co.	298			Oil
52	Posey	9	7S	13W	2,808	Pennsylvanian	Ste. Genevieve	Farm Bureau Oil Co. Inc.				Dry
53	St. Joseph	20	38N	4E	1,045	Mississippian	Trenton	M. C. Pletcher				Dry
54	Spencer	3	4S	5W	1,220	Pennsylvanian	Ste. Genevieve	The Texas Co.				Dry

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1944

Line Number	County	Location Sec.	Location Twp.	Location Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day Oil, U.S. Bbl.	Initial Production per Day Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Remarks
55	Spencer.........	25	4S	5W	544	Pennsylvanian	Upper Chester	The Texas Co.				Dry
56	Spencer.........	2	5S	5W	1,133	Pennsylvanian	Ste. Genevieve	The Texas Co.				Dry
57	Spencer.........	32	6S	5W	1,210	Pennsylvanian	Ste. Genevieve	C. V. Guthrie				Dry
58	Sullivan.........	10	6N	10W	2,808	Pennsylvanian	Devonian	J. W. Rudy				Dry
59	Sullivan.........	14	6N	10W	2,845	Pennsylvanian	Devonian	The Texas Co.				Dry
60	Sullivan.........	33	8N	10W	2,834	Pennsylvanian	Devonian	The Texas Co.				Dry
61	Sullivan.........	9	9N	8W	2,241	Pennsylvanian	Devonian	The Texas Co.				Dry
62	Sullivan.........	8	9N	9W	2,480	Pennsylvanian	Devonian	Farm Bureau Oil Co. Inc.				Dry
63	Sullivan.........	3	9N	10W	2,388	Pennsylvanian	Devonian	Patti Humphreys				Dry
64	Tippecanoe......	10	24N	3W	906	Devonian	Trenton	Arthur Wolf, Fee				Dry
65	Vanderburgh....	22	5S	11W	2,544	Pennsylvanian	Ste. Genevieve	Sun Oil Co.				Dry
66	Vanderburgh....	25	5S	11W	2,562	Pennsylvanian	Ste. Genevieve	Jarvis & Marcell				Dry
67	Vanderburgh....	1	7S	10W	2,370	Pennsylvanian	Ste. Genevieve	Ryan Oil Co.				Dry
68	Wabash.........	12	27N	5E	890	Silurian	Trenton	F. C. Weaver				Dry
69	Wabash.........	33	27N	6E	987	Silurian	Trenton	The Texas Co.				Dry
70	Wabash.........	19	27N	8E	985	Silurian	Trenton	The Texas Co.				Dry
71	Wabash.........	1	28N	6E	1,106	Silurian	Trenton	The Texas Co.				Dry
72	Wabash.........	24	28N	6E	1,067	Silurian	Trenton	The Texas Co.				Dry
73	Warrick.........	26	4S	9W	1,917	Pennsylvanian	Ste. Genevieve	Highland Oil Co.				Dry
74	Warrick.........	8	5S	7W	1,775	Pennsylvanian	Ste. Genevieve	Cherry & Kidd and Ashland Ref. Co.				Dry
75	Warrick.........	23	6S	8W	1,886	Pennsylvanian	Ste. Genevieve	Eureka Oil Co.				Dry
76	Warrick.........	27	5S	8W	1,913	Pennsylvanian	Ste. Genevieve	Sunlight Coal Co.				Dry
77	Wells...........	8	27N	13E	1,185	Silurian	Trenton					Dry
78	Wells...........	31	28N	13E	1,297	Silurian	Trenton					Dry

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944..........	220	85
Number of oil wells completed during 1944..........	144	10
Number of gas wells completed during 1944..........	26	1
Number of dry holes completed during 1944..........	160	66

TABLE 3.—*Completions by Counties in Indiana for* 1944

County	Completions	Producers Oil	Producers Gas	Total Initial Daily Production of Oil, Bbl.	Total Initial Daily Production of Gas, M. Cu. Ft.	Total Footage	County	Completions	Producers Oil	Producers Gas	Total Initial Daily Production of Oil, Bbl.	Total Initial Daily Production of Gas, M. Cu. Ft.	Total Footage
Adams........	2	0	0			3,650	Martin.........	2	0	1		5	1,163
Carroll........	1	0	0			610	Orange.........	1	0	0			1,517
Crawford......	1	0	0			360	Owen..........	2	0	0			5,108
Daviess........	14	6	0	82		13,110	Parke..........	2	0	0			3,204
Decatur........	9	0	9		1,024	8,207	Perry..........	5	0	0			6,306
Delaware......	1	1		25		1,923	Pike...........	19	13	1	166	500	24,673
Dubois........	2	0	0			4,694	Porter.........	1	0	0			1,115
Gibson........	89	54	2	4,339	840	179,854	Posey..........	89	52	1	6,645	5	224,047
Grant.........	1	0	0			1,044	Spencer........	20	8	1	84	2,680	22,806
Greene........	5	1	1	30	451	7,224	St. Joseph......	1	0	0			1,045
Harrison.......	4	0	3		105	2,585	Sullivan........	8	0	0			18,829
Howard.......	1	0	1		50	918	Tippecanoe.....	1	0	0			906
Huntington....	1	0	0			1,048	Vanderburgh...	3	0	0			7,476
Jackson........	1	0	0			425	Wabash........	5	0	0			5,035
Jay...........	12	6	6	101	1,700	15,642	Warrick........	5	0	0			8,754
Jefferson.......	1	0	0			135	Wells..........	9	0	0			10,270
Jennings.......	1	0	1		20	930	White..........	1	0	0			135
Knox..........	10	4	1	436	20	20,158							
La Porte.......	1	0	0			460		331	145	28	11,908	7,400	606,720

TABLE 4.—*Completions in Indiana in* 1944

Line Number	County, Farm Name, Location	No. of Wells	Type of Wells: Oil	Gas	Dry	Wild-cat	Initial Production	Producing Horizon	To Top, Ft.	Name of Field	Total Depth, Ft.
							BARRELS				
	Adams County										
1	Rufus Glendenning, 35-25N-13E...	1			1	1		Top Cambrian	2,244	Trenton	2,510
2	Jacob and Fannie Swartz, 23-26N-13E..........	1			1			Trenton H. F. W.	1,119 1,137	– Trenton	1,140
	Carroll County										
3	Frank L. Shepard, 23-25N-3W.....	1			1	1		Top Niagara			610
	Crawford County										
4	Ray Goldman, 18-3S-1W..........	1			1	1					360
	Daviess County										
5	Wm. Beck Heirs, 8-2N-5W........	5	1				20	Barlow	617	Cannelburg	650
6	Wm. Beck Heirs, 8-2N-5W........	6	1				10	Golconda Saturation	544–555 638–648	Cannelburg	648
7	Wm. Beck Heirs, 8-2N-5W........	7	1				10	Bethel sand	616–630	Cannelburg	630
8	Geo. F. and M. I. O'Brien, 17-2N-5W	3	1				4	Golconda	560–572	Cannelburg	682
9	Joseph Disser, 15-2N-6W..........	1			1			Cypress sand	722–738	Glendale, North	1,018
10	R. D. Brown, Inc., Fee, (Anna Disser Farm), 16-2N-6W..............	1			1			McClosky	874	Glendale, North	876
11	Joseph and Mary Disser, 16-2N-6W	1			1			Brown lime	714	Glendale, North	820
12	N. B. Kelly, 16-2N-6W............	1			1			Ste. Genevieve	878[1]	Glendale, North	979
13	R. C. Snider, 16-2N-6W...........	1	1				8	Cypress sand	788–793	Glendale	793
14	Chlora E. Winterbottom, 16-2N-7W	1			1			McClosky	1,181–1,185	Veale	1,430
15	Margaret Graham, 17-2N-7W......	1	1				30	Ste. Genevieve Testing McClosky	1,148 1,197–1,205	Veale	1,205
16	Margaret Graham, 17-2N-7W......	2			1					Veale	1,258
17	Cameron and Laura J. Hyatt, 17-2N-7W..........................	1			1			McClosky	1,261–1,266 S.O.	Veale	1,345
18	Joel Knepp, 22-3N-6W............	1			1	1		P. C. sand	762–776		776
							CU. FT.				
	Decatur County										
19	Joseph A. and Olivia Rethlake, 13-9N-9E......................	243		1			142,000	Trenton		Greensburg Gas	920
20	Marvin Ray, 7-9N-10E...........	241		1			122,000	Trenton		Greensburg Gas	863
21	Marvin Ray, 7-9N-10E...........	242		1			46,400	Trenton		Greensburg Gas	896
22	Wm. and Dinah Ruhl, 13-9N-9E...	244		1			107,500	Trenton	866–909	Greensburg Gas	909
23	Edward F. and Tillie J. Griffin, 15-9N-9E.....................	245		1			134,600	Trenton		Greensburg Gas	918
24	Ferdinand and Ida Buening, 22-9N-9E..........................	1		1			150,000	Trenton	870	Greensburg Gas	891
25	Frank Schwering, 23-9N-9E.......	246		1			111,500	Trenton	854	Greensburg Gas	904.75
26	Mrs. Frank Walker, 36-10N-9E....	239		1			83,700	Trenton	917	Greensburg Gas	957
27	Edith B. Weber, 30-10N-10E......	240		1			126,400	Trenton	903	Greensburg Gas	949
							BARRELS				
	Delaware County										
28	C. M. Kinzie, 24-1N-6W..........	1	1				25	Trenton		Trenton	1,923

	Dubois County										
29	Ora B. Wilson, 24-1N-6W	1			1	1		Bethel	783		891
30	A. Luebbehuesen, 35-3S-5W	1			1	1		Trenton	3,685		3,803
	Gibson County										
31	Oscar and Edith Phillips, Don. 98-1N-10W	1			1			McClosky	1,819–1,824	Hazleton	1,835
32	Hugh Kirk, Don. 114-1N-10W	2	1				28	McClosky	1,780	Hazleton	1,790
33	Hugh Kirk, Don. 114-1N-10W	3	1				16	McClosky	1,852–1,857	Hazleton	1,875
34	Sam and Rosetta Cunningham, Loc. 115(35)-1N-10W	1	1				15	McClosky	1,843–1,848	Union-Bowman	1,848
35	Gladys Kerr and Nellie Ginder, 26-1N-10W.	2	1				8	McClosky Salem	1,678 1,972	Hazleton	2,042
36	George W. Schoultz, 16-1S-9W	2			1			McClosky	1,650	Owensville, North	1,686
37	Mattie Dillon, 16-1S-9W	1			1			Golconda	1,394	Union-Bowman	1,505
38	R. M. Boswell, 17-1S-9W	1			1			McClosky	1,630 S.S.O.	Wheeling	1,698
39	Marion Hunt, 20-1S-9W	4			1			Cypress	1,358–1,365	Wheeling	123
40	A. J. Coleman, 1-2S-10W	4	1				30	Hardinsburg		Kirksville	1,354
41	Marion Hunt, 20-1S-9W	7	1				15	Hardinsburg	1,282–1,297 S.O.	Wheeling	1,297
42	Marion Hunt, 20-1S-9W	8	1				20	Hardinsburg	1,290–1,300 S.O.	Wheeling	1,300
43	Mary Jane Schoultz, 16-1S-9W	1	1				10	Hardinsburg	1,279–1,294 sat.	Wheeling	1,296
44	Lennis Shoultz, 16-1S-9W	1	1				34	McClosky	1,607–1,699 S.S.O.	Oatesville	1,699
45	Guy Warner Schoultz, 17-1S-9W	1	1				35	Hardinsburg	1,268–1,273	Oatesville	1,273
46	Guy Warner Schoultz, 17-1S-9W	2	1				20	Hardinsburg	1,294–1,308	Oatesville	1,308
47	G. W. Schoultz, 17-1S-9W	5	1				40	Hardinsburg	1,278–1,296	Oatesville	1,296
48	Marion Hunt, 20-1S-9W	9			1			Cypress sand	1,379–1,390	Wheeling	1,393
49	George and Edith B. Cloin, 21-1S-9W	2	1				45	Hardinsburg	1,260–1,295 sat.	Wheeling, East	1,295
50	George and Edith B. Cloin, 21-1S-9W	3			1			Hardinsburg	1,242	Wheeling, East	1,382
							Cu. Ft.				
51	Elzie Ligier, 35-1S-10W	1		1			340,000			Kirksville	675
52	Henry Crecelius, 36-1S-10W	4			1			Hardinsburg	1,298–1,324	Kirksville	1,387
53	Martha Mahan, 36-1S-10W	4			1			Cypress	1,552–1,553	Kirksville	1,572
54	Martha Mahan, 36-1S-10W	5			1			Hardinsburg	1,315	Kirksville	1,400
55	Myrtle Hall, et al., 20-1S-11W	2			1			Salem	2,622	Patoka	3,062
56	J. F. Hull, 23-1S-11W	1			1			Glen Dean		Patoka	1,880
57	Deep Vein Coal Co., 25-1S-12W	1			1	1		St. Louis			2,400
58	Laura Roush, 17-2S-8W	1			1					Oakland City	1,675
							Barrels				
59	Arthur J. Coleman, 1-2S-10W	2	1				70	Hardinsburg	1,248–1,339–1,348	Kirksville	1,348
60	Arthur J. Coleman, 1-2S-10W	3	1				35	Hardinsburg	1,300–1,318 water	Kirksville	1,348
61	Arthur J. Coleman, 1-2S-10W	5			1			Glen Dean	1,298–1,312	Kirksville	1,390
62	Edward W. Moore, 1-2S-10W	1			1			Hardinsburg	1,309		1,415
							Cu. Ft.				
63	Robert C. and Jane M. Duncan, 2-2S-10W	1		1			500,000	Glen Dean	1,318	Kirksville	1,610
							Barrels				
64	Armstrong Unit, 19-2S-11W	1	1				391	Bethel sand McClosky	2,112–2,122 2,305–2,307	Owensville, North Extension	2,322
65	Armstrong Unit, 19-2S-11W	2	1				80	Cypress sand	1,954–1,965	Owensville, North Extension	2,150

[1] Sulphur water at 976 feet.

TABLE 4.—(*Continued*)

Line Number	County, Farm Name, Location	No. of Wells	Type of Wells: Oil	Gas	Dry	Wild-cat	Initial Production	Producing Horizon	To Top, Ft.	Name of Field	Total Depth, Ft.
							BARRELS				
66	Armstrong Unit, 19-2S-11W	3	1				204	Cypress sand Bethel sand	1,958–1,969 2,116–2,132	Owensville, North Extension	2,154
67	May Mauck, 19-2S-11W	1	1				130	Cypress Bethel	1,958–1,973 2,110–2,120	Owensville, North Extension	2,155
68	Morton and Florence Woods, 30-2S-11W.	2	1				50	Cypress sand Bethel sand	1,973–1,977 sat. 2,104 show	Owensville, North Extension	2,140
69	Laura Marvel, 30-2S-11W	1	1				54	Bethel sand and McClosky	2,153–2,159 2,144–2,151 2,299–2,305	Owensville, North Extension	2,316
70	Marvel-Brazelton Unit, 30-2S-11W	1	1				14	Cypress sand	Ren. 2,165	Owensville, East Extension	2,172
71	Marvel-Brazelton Unit, 30-2S-11W	2	1				14	Cypress sand	1,968–1,975 S.O.	Owensville, North Extension	2,151
72	Paul Brazelton, 30-2S-11W	2			1		3	McClosky lime	2,299–2,302	Owensville, North Extension	2,310
73	Mabel Marvel Unit, 30-2S-11W	1	1				176 o. 4 w.	Bethel Sand Paint Creek and Cypress		Owensville, North East Extension	2,338
74	Mabel Marvel Unit, 30-2S-11W	2	1				235 o. 5 w.	McClosky	2,289–2,295	Owensville, North East Extension	2,301
75	William Marvel Unit, 30-2S-11W	1	1				323	Cypress sand; Bethel sand and McClosky lime		Owensville, North East Extension	2,356
76	Flora Clark, 30-2S-11W	1	1				375[2]	P. C. sand, McClosky lime		Owensville, North	2,316
77	Morton and Florence Woods, 30-2S-11W.	1	1				40	Cypress, Barlow	1,961–1,980	Owensville, North East Extension	1,987
78	Madison M. and Amanda E. Knowles, 32-2S-11W	1			1	1		McClosky	2,409–2,413		2,452
79	Permelia Massey Unit, 25-2S-12W	1	1				70	Cypress sand	2,035–2,044	Owensville, North	2,046
80	Permelia Massey Unit, 25-2S-12W	2			1			Cypress sand	2,059 S.O.	Owensville, North	2,070
81	Flora Mounts Unit, 25-2S-12W	1	1				13 in 12 hr. cut 10 % B.S.	Cypress sand	1,985–1,992	Owensville, North	1,995
82	Leonard Stewart, 25-2S-12W	1			1			Ste. Genevieve	2,332	Owensville, North	2,451
83	Ellis Thompson, 25-2S-12W	2			1			Cypress sand	1,969–1,983 S.O.	Owensville, North	1,985
84	Ellis Thompson, 25-2S-12W	3	1				12	Bethel sand McClosky	2,331–2,334	Owensville, North	2,341
85	Eugene Thompson Unit, 25-2S-12W	1	1				45	Cypress sand	1,961–1,970 sat.	Owensville, North	1,974
86	Eugene Thompson Unit, 25-2S-12W	2	1				150	Cypress sand	1,950–1,975 S.O.	Owensville, North	1,975
87	S. B. Thompson Unit, 25-2S-12W	3	1				30	Cypress sand	2,017–2,026 sat.	Owensville, North	2,026
88	C. W. Yeager Unit, 25-2S-12W	2	1				50	Cypress sand	1,975–1,985	Owensville, North	1,985
89	E. J. Lewis, et al., 36-2S-12W	1			1			McClosky	2,442–2,445		2,485
90	Amanta Maier, 31-2S-13W	62	1				142	Cypress sand	2,490–2,502	Griffin	2,502
91	Amanta Maier, 31-2S-13W	63			1			Aux Vases	2,712	Griffin	2,797
92	Federal Farm Mortgage Co., 33-3S-9W	1			1	1		St. Louis	2,084		2,085
93	Virginia R. Baird, 25-3S-12W	1	1			1	150	McClosky lime	2,513–2,518 S.S.O. 2,514		2,527

94	Virginia R. Baird, 30-3S-11W	2			I			St. Louis	2,602	Owensville, South	2,610
95	Archie Thompson, 11-31S-12W	1			I	I					1,202
96	Adam B. Dawson, 25-3S-12W	1	I			I	220	McClosky	2,507		2,521
97		1	I				50	McClosky	2,513–2,522		2,524
98		1			I			McClosky	2,530–2,539 S.O.		2,630
99	Louis and D. Marvel, 26-3S-12W	1			I	I		McClosky	2,676		2,697
100	Mabel Redman, 27-3S-12W	1			I	I		St. Louis lime	2,725		2,729
101	Wm. and Mary Dunn, 18-3S-13W	2			I			Hardinsburg	2,301	Griffin	2,305
102	Wm. and Mary Dunn, 18-3S-13W	8	I				11	Hardinsburg	2,295 S.O.	Griffin	2,303
103	Cooper Estate, 18-3S-13W	4	I				105	Hardinsburg	2,275	Griffin	2,301
104	Amanta Maier, 11-3S-14W	64	I				142	Cypress	2,491–2,507 sat.	Griffin	2,507
105	Amanta Maier, 11-3S-14W	65	I				44	Cypress sand	2,497–2,511 sat.	Griffin	2,511
106	Amanta Maier, 12-3S-14W	66	I				81	Cypress sand	2,484–2,505 sat.	Griffin	2,508
107	Amanta Maier, 11-3S-14W	68	I				57	Cypress	2,495–2,513	Griffin	2,513
108	D. M. Cooper, 12-3S-14W	8	I				27	Cypress	2,510–2,524 S.S.O.	Griffin	2,536
109	D. M. Cooper, 13-3S-14W	D-16			I			Cypress sand	2,477	Griffin	2,509
110	State of Indiana	1			I					Griffin	3,309
111	Bozeman Land Co., 23-3S-14W	66	I				71	Waltersburg	2,073–2,093	Griffin	2,096
112	Bozeman Land Co., 24-3S-14W	68	I				58	Waltersburg	2,073–2,086	Griffin	2,094
113	Bozeman Land Co., 23-3S-14W	69	I				108	Aux Vases	2,763	Griffin	2,784
114	Bozeman Land Co., 24-3S-14W	70	I				44	Aux Vases	2,782–2,787	Griffin	2,810
115	Bozeman Land Co., 26-3S-14W	71			I			Aux Vases	2,764–2,780	Griffin	2,792
116	Bozeman Land Co., 24-3S-14W	72	I				41	Waltersburg and Aux Vases	2,765–2,791 sat.	Griffin	2,793
117	Bozeman Land Co., 25-3S-14W	73	I				21	Waltersburg	2,090–2,104 o.	Griffin	2,107
118	Bozeman Land Co., 26-3S-14W	74	I				13	Waltersburg sand	2,050–2,070	Griffin	2,082
119	Bozeman Land Co., 26-3S-14W	75	I				64	Waltersburg sand	2,080–2,103 o.	Griffin	2,108
	Grant County										
120	Clara Knight, et al., 8-23N-8E	1			I	I		Show oil and gas	994–1,011		1,044
	Greene County										
121	Roy Frakes, et al., 21-7N-6W	1			I	I		Devonian lime	1,785		1,900
122	Sabitha and Norman Jones, 23-7N-4W	1			I	I		Devonian	1,392		1,504
123	Cyrus E. Davis, et al., 15-7N-6W	2		I		I	Cu. Ft. 351,000	Devonian	1,666 (Test well)		1,720
124	Joe Newby, 24-19N-3W	1			I			Trenton		Horton	1,037
125	Joe Newby, 24-19N-3W	2	I				100,000 (and 30 bbl. o.)			Horton	1,063
	Harrison County										
126	Mamie Hilderbrand, 2-5S-4E	1		I			30,000	New Albany shale	554–568	Laconia Gas	568
127	James Livingston, 2-5S-4E	1		I			35,000	New Albany shale	630	Laconia Gas	653
128	Mary McFarland, 2-5S-4E	1		I			40,000	New Albany shale		Laconia Gas	572
129	Ira O. and Amelia Shumaker, 3-5S-4E	1			I			New Albany shale	694	Laconia Gas	792
	Howard County										
130	Willard E. Stahl, 8-23N-4E	1		I			50,000	Trenton		Trenton	918
	Huntington County										
131	M. H. Hacker, 21-27N-9E	1			I	I		Trenton	1,019		1,048
	Jackson County										
132	George B. Lucas, 16-6N-4E	1			I	I					425
	Jay County										
133	Audry Landis, 35-22N-12E	1		I			40,000			Trenton	997
134	Charles Barger, 1-22N-15E	2	I	I			8,000 (and 7 bbl. o.)	Trenton	1,076	Henderson pool	1,132

[2] Flowed.

TABLE 4.—(*Continued*)

Line Number	County, Farm Name, Location	No. of Wells	Type of Wells: Oil	Gas	Dry	Wild-cat	Initial Production	Producing Horizon	To Top, Ft.	Name of Field	Total Depth, Ft.
135	Luther Berrymier, 5-22N-15E......	1		1			800,000	Trenton	1,032	Trenton	1,135
136	Willie and Grace Magill, 22-23N-13E	1			1			Trenton	940	Trenton	1,035
							BARRELS				
137	Forrest Theurer, 22-23N-15E......	1	1			1	15	Trenton	1,103		1,181
138	Forrest Theurer, 22-23N-15E......	2	1				15	Trenton		Trenton	1,187
139	I. C. Rockwell, 23-23N-15E........	1	1				7	Trenton	1,090	Trenton	1,154
140	Chas. W. Darst, 26-23N-15E.......	1		1			5 (and 500,000 cu. ft. g.)	Trenton	1,041 g.	Trenton area	1,098
141	Chas. W. Darst, 26-23N-15E.......	2		1			5 (and 350,000 cu. ft. g.)	Trenton	1,044–1,093	Trenton area	1,093
142	Jacob Zimmerman, 35-23N-15E....	1	1				25	Trenton	1,047	Henderson pool	1,109
143	Floyd Freemyer, Fractional, 36-23N-15E.	2	1				22	Trenton	1,069–1,116 g. and o.	Henderson pool	1,126
144	Jacob and Gladys Binegar, 29-24N-13E.	1			1			St. Peter	1,444–1,532	Trenton	
								Cambrian sand	2,840–3,333		3,395
	Jefferson County										
145	Wm. W. Copeland Fee, 9-4N-9E...	2			1		(Water well)				135
							CU. FT.				
146	*Jennings County*										
	Gilbert Hahn, 11-8N-9E...........	1		1			20,000			Trenton	930
							BARRELS				
	Knox County										
147	Wm. P. Steckler, et al., 35-1N-12W	1	1			1	25	Biehl sand	1,407–1,419		1,419
148	Chas. and Wilma Thompson, 35-1N-12W........................	1			1			McClosky sand	2,269–2,274 S.O.	Mt. Carmel	2,314
149	John M. Brevoort, 23-2N-11W.....	1			1			McClosky	1,916–1,920 water	St. Thomas	1,960
150	Emma C. Cunningham, 36-2N-11W	1			1			McClosky	1,861–1,866 show	St. Thomas	1,885
151	Bailey M. McDowell, 36-2N-11W..	1	1				22	McClosky	1,857–1,867 sat.	St. Thomas	1,867
152	John M. Brevoort, Survey 16-3N-10W........................	1			1	1					1,951
153	L. B. McDonald, Don. 29-3N-9W..	1			1	1					1,742
154	David A. Upham Estate, 3-1S-12W	1			1			McClosky	2,315–2,317 S.S.O.	Mt. Carmel	2,349
155	George and Lula B. Wilson, 4-1S-12W.	3	1				384	McClosky	2,303–2,309 S.O.		
								St. Louis	2,314		2,317
156	Lula B. Wilson, 4-1S-12W.........	4		1				McClosky	2,324–2,348	Mt. Carmel	2,354
	La Porte County										
157	Martha Fischer, 19-37N-2W.......	1	1				5	Devonian lime	428		
								Good show of oil	448		460
	Martin County										
							CU. FT.				
158	George P. Jennings, 25-3N-5W.....	1			1	1		McClosky	552 water		593
159	Emmett D. Yarnell, 25-3N-5W.....	1		1			5,000 or 6,000	Ste. Genevieve	570	Loogootee	570
	Orange County										
160	Cora M. Brothers, 19-3N-2W......	1			1	1		Devonian	1,275		1,517

	Owen County										
161	J. Fiscus, 2-9N-5W	I			I	I		Trenton	2,334		2,515
162	S. A. Nugent, 3-9N-5W	I			I	I		Trenton	2,297–2,395		2,593
	Parke County										
163	Clara May Rohm, 15-15N-8W	I			I	I		Devonian lime	1,302		1,700
164	Cal Bartlow, et al., 16-16N-8W	I			I	I	(Comp. as water well)	Devonian	1,191		1,504
	Perry County										
165	Henry Delaisse, 25-4S-3W	I			I	I		Trenton	3,151	Bristow	3,255
166	Wm. A. Graves, 17-5S-2W	I			I	I		McClosky	663–719		719
167	Frank and Minnie Leucke, 31-5S-2W	I			I	I					692
168	John Klien, 31-5S-3W	I			I			Ste. Genevieve	634	East Troy	770
169	Walter Tableman, 28-6S-3W	I			I			Barlow	656	East Troy	870
	Pike County										
170	Carl and Naomi Frederick, Loc. 11 (28)-1N-9W	I			I		(Deepened)	Osage	2,208–2,211 S.O.	Union-Bowman	627
							BARRELS				
171	Della M. Kime, Loc. 12-1N-9W	B-1	I				6	Hardinsburg sand		Union-Bowman	1,231
172	John McAtee, et al., Loc. 146-1N-9W	B-2	I				14	Pennsylvanian	1,020–1,031	Union-Bowman	1,031
173	John McAtee, Loc. 146-1N-9W	B-3	I				15	Oil sand	1,025–1,028	Union-Bowman	1,028
174	Mary McAtee, Loc. 146-1N-9W	B-4	I				10	McClosky	1,627–1,668	Union-Bowman	1,668
175	Reubie and Harley Garrison, Comm., 24-1N-7W	I			I			Show gas and oil	938–940	Iva East	992
176	John A. Sutton and Wife, and other Lessors-Sutton Comm., 30-1N-8W	I			I			McClosky	1,451–1,460 S.O.	Union-Bowman	1,789
177	L. O. Dickerman, 32-1N-9W	I	I				25	Bethel sand	1,497–1,530	Union-Bowman	1,530
178	J. W. Peed, 32-1N-9W	2	I				18	Hardinsburg sand	1,261		1,261
179	J. W. Peed, 32-1N-9W	3	I				25	McClosky	1,680–1,694	Union-Bowman	1,721
180	Warner and Margaret Robling, 32-1N-9W.	I	I				6	McClosky and Aux Vases		Union-Bowman	1,686
181	John and Allie McAtee, 33-1N-9W	7	I				7	McClosky	1,625–1,631	Union-Bowman	1,631
182	Chas. Knick, 8-1S-7W	I	I			I	18	Cypress sand	1,135–1,139		1,139
183	Elizabeth Atkinson, 22-1S-9W	10	I				1	Cypress sand	997–1,019 sat.	Oatesville	1,019
184	D. S. Huey, 27-1S-9W	12	I				7	Cypress sand	1,253–1,275 S.O.	Oatesville, North	1,275
185	N. W. Shafer, 27-1S-9W	6	I				14	Cypress sand	1,305–1,313	Oatesville	1,313
186	Emil Kemper, 9-3S-6W	I			I	I		St. Louis	1,330–1,375.5		1,377
							CU. FT.				
187	Sarah Rodemacher and Lorina K. Betts, 15-3S-7W.	I		I	I		500,000	Tar Springs sand	826–836 show gas	Stendal	1,170
188	Theodore Roy and Enos Coal Co., 16-3S-7W	I			I			Barlow lime	1,130	Spurgeon	1,185
	Porter County										
189	Walter and Francis Egelske, 9-36N-5W.	I			I	I		Trenton Sulphur water	1,050 1,115.5		1,115.5
							BARRELS				
	Posey County										
190	Blanche M. Doll, 33-3S-14W	18	I				35	Aux Vases	2,784	Griffin	2,808
191	L. P. Kleiderer, 33-3S-14W	A-19	I				54	Ste. Genevieve		Griffin	2,817
192	Grover & Frank Keck, 34-3S-14W	I	I		I			Ste. Genevieve	2,819	Griffin	2,900
193	Louise Hill, 7-4S-13W	I			I	I		McClosky	2,898–2,901		2,975
194	Wm. Bantz, 28-4S-13W	I	I				85	Waltersburg sand	2,192–2,204	Rogers East	2,204
195	Lincoln and May Ford, 30-4S-13W	I			I			Ste. Genevieve	2,875	Rogers East	2,927
196	Jacob Kemmerling, 31-4S-13W	I			I	I		Fredonia	2,872		2,984
197	Ed. Swonder, 4-4S-14W	14	I				23	Aux Vases	2,798–2,802	Griffin	2,825
198	Chas. Murphy and L. Hill Comm., 7-4S-13W	I			I	I		St. Louis lime	2,998		3,032
199	Ed. Swonder, 4-4S-14W	15			I		3	Aux Vases	2,751–2,777 S.O.	Griffin	2,935

TABLE 4.—(*Continued*)

Line Number	County, Farm Name, Location	No. of Wells	Type of Wells: Oil	Gas	Dry	Wild-cat	Initial Production	Producing Horizon	To Top, Ft.	Name of Field	Total Depth, Ft.
200	H. H. Kratz and Basil McCoy, 10-4S-14W	1			1			Ste. Genevieve	2,864	Griffin	3,003
201	New Harmony Realty Co., 34-4S-14W	34	1				155	McClosky lime	2,974–2,979	New Harmony	3,091
202	James Garris, 4-5S-12W	1			1	1		Cypress sand	2,411–2,421 S.O.		2,769
203	Clarence E. Reich, et al., 27-5S-12W	1			1	1		St. Louis	2,721		2,735
204	Edward Daudistel, 32-5S-13W	1			1	1		St. Louis	2,966–2,972		3,049
205	New Harmony Realty Co., 3-5S-14W	36			1			McClosky	3,084–3,086	New Harmony	3,212
206	Chas. Hempfling, 11-5S-14W	1			1			Hardinsburg	2,480	New Harmony, South	2,495
207	Elmer E. Elliott, 14-5S-14W	1			1		-	Hardinsburg	2,479–2,481	New Harmony, South	2,499
208	Elmer E. Elliott, 14-5S-14W	1	1				125	Hardinsburg	2,362–2,370 S.O.	New Harmony, South	2,395
209	Elmer E. Elliott, 14-5S-14W	2	1				60	Hardinsburg	2,416–2,425 sat.	New Harmony, South	2,429
210	Elmer E. Elliott, 14-5S-14W	3	1				40 swb.	Hardinsburg	2,407–2,422 S.O.	New Harmony, South	2,424
211	Willis Hickam, 14-5S-14W	1			1			Hardinsburg	2,451–2,456	New Harmony, East Extension	2,470
212	Hickam Elliott, 14-5S-14W	2			1			Cypress sand	2,704–2,708	New Harmony, South	2,708
213	Herman Wade, et al., 14-5S-14W	1	1	(Discovery well)		1	298	Hardinsburg	2,444–2,469	New Harmony, South	2,469
214	Arthur Rutledge and H. Wade, et al., 14-5S-14W.	Unit 3	1				100	Hardinsburg	2,401–2,416	New Harmony, South	2,430
215	Arthur Rutledge and H. Wade, Comm., 14-5S-14W.	Unit 2	1				150	Degonia	1,916–1,928	New Harmony, South	2,401
216	Arthur Rutledge and H. Wade, et al., 14-5S-14W.	Unit 4			1			Hardinsburg	2,448–2,456 S.O.	New Harmony, South	2,464
217	Walgrove Corp., 14-5S-14W	1			1			McClosky	2,962–2,968	New Harmony, South	2,975
218	New Harmony Realty Co., 17-5S-14W	35			1			McClosky	2,989–2,993 S.O.	New Harmony	3,155
219	E. E. Elliott, 23-5S-14W	1			1			Ste. Genevieve	2,948	New Harmony, South Extension	3,150
220	Barbara Korsmeier, 2-6S-12W	1			1	1		St. Louis	2,734		2,738
221	Arthur Seifert, 20-6S-12W	1			1			McClosky	2,639–2,653 S.O.	Caborn	1,243
222	Sadie Ashworth, 14-6S-12W	1			1	1		Ste. Genevieve	2,670		2,695
223	Elizabeth Esche, 19-6S-12W	1			1			Cypress sand	2,457–2,466	Bufkin	2,763
224	Phillip Mertens, 17-6S-12W	1	1				25	Cypress sand	2,338–2,351	Caborn	2,353
225	Arthur Seifert, 20-6S-12W	2		1			Cu. Ft. 5,000 Barrels			Caborn	292
226	Anna Junker, 24-6S-13W	1			1		2			Heusler	1,170
227	Lydia Schreiber, 30-6S-12W	2			1			Waltersburg	1,911	Caborn	1,915
228	Ray Newman, 36-6S-12W	2	1				125	Tar Springs sand	1,891–1,900	Heusler	1,900
229	J. A. Gumbel, 36-6S-12W	1			1			Tar Springs sand	1,902–1,917 S.O.	Heusler	1,917

230	Ray Newman and C. A. Maloot	1	1				10	Waltersburg	1,784	Heusler	1,797
231	A. V. Price and M. E. Downen, 25-6S-13W	1	1				55	Dolomite	1,153	Caborn	1,153
232	Hugh and Delores Wiseman, 27-6S-14W.	1			1	1		McClosky	2,890–2,898 S.S.O.		2,971
233	Dora Helm, 15-6S-14W	1			1			St. Louis	2,984	Welborn	2,995
234	Irene Schultz, 29-6S-14W	1	1				48	Aux Vases McClosky	2,741 2,866–2,869	Upton	2,869
235	J. W. Mann, 5-7S-14W	B-1			1			Aux Vases	2,778–2,779	Mt. Vernon	2,962
236	J. W. Mann, 5-7S-14W	2	1				800	Waltersburg sand	2,096–2,110	Mt. Vernon	2,110
237	J. W. Mann, et al., 5-7S-14W	3	1				500[2]	Waltersburg sand	2,063–2,075 S.O. 2,080–2,096	Mt. Vernon	2,096
238	Deakin and Lynch, 25-7S-15W	1	1			1	55	McClosky	2,808		2,850
239	Manson Reichert, 25-7S-15W	1			1	1		McClosky	2,794–2,798 S.O.		2,850
240	Henry W. Elbert and Chas. Pollard, 36-8S-14W	1			1	1		Upper Menard	1,690		2,317
241	Henry W. Elbert and Chas. Pollard, 36-8S-14W	2			1	1					2,756
242	Will Espenshied, 5-7S-14W	1	1				40 swb.	Tar Springs sand	2,131–2,147 S.O.	Prairie	2,152
243	Wm. Espenshied, 5-7S-14W	1			1(?)			Waltersburg sand	2,100–2,107	Mt. Vernon	2,789
244	Roah M. Gould, 32-6S-14W	1	1				32	St. Louis	2,975	Upton	2,982
245	Davis Rosenbaum, 32-6S-14W	1	1			1	85 swb.	Aux Vases and Tar Springs	2,146–2,157 S.O.		2,788
246	J. W. Spencer, and A. Vogel, 32-6S-14W	3	1				250	Waltersburg sand	2,068–2,106	Prairie	2,143
247	J. W. Spencer and A. Vogel, 32-6S-14W	2	1			1	200	Waltersburg sand	2,068–2,105		2,110
248	Herman and Jesse Rosenbaum, 33-6S-14W.	1			1			Cypress sand Rosi	2,413–2,417 S.O. 2,680–2,682	Caborn	2,805
249	Wm. E. Hill, 18-7S-12W	1			1			St. Louis	2,773–2,776	Lamott	2,776
250	Casper Graulick, 9-7S-13W	1			1	1		St. Louis	2,787–2,790		2,808
251	Henry H. Lang, 5-7S-14W	1	1				168	Tar Springs sand	2,133–2,141 S.O.	Prairie	2,150
252	Henry H. Lang, 5-7S-14W	2	1				185	Tar Springs sand	2,130	Prairie	2,143
253	J. W. Spencer, Jr., 1-7S-14W	1	1				144	Cypress sand	2,518–2,553	Mt. Vernon	2,558
254	Joseph W. Mann, 5-7S-14W	1	1				48	Cypress sand	2,480–2,489 S.O.	Mt. Vernon	2,493
255	Henry R. Skiles and Elizabeth Mackey, 15-8S-15W.	1	1				23	Tar Springs Aux Vases	2,031–2,051 2,641–2,667	Inman East	2,666
256	Henry R. Skiles, State of Indiana and Elizabeth Mackey, 15-8S-15W	1	1				113 swb.	Waltersburg sand, Tar Springs sand	S.O.	Inman East	2,670
257	Henry R. Skiles and State of Indiana, 15-8S-15W.	1	1				176	Waltersburg sand Tar Springs sand	1,954–1,970 2,048–2,068	Inman East	2,412
258	Henry R. Skiles and State of Indiana, 15-8S-15W.	2	1				120 swb.	Waltersburg sand, Tar Springs and Cypress sand, Aux Vases		Inman East	2,676
259	Henry R. Skiles and State of Indiana, 15-8S-15W.	3	1				168 swb.	Waltersburg and Cypress sand		Inman East	2,403
260	Henry R. Skiles and State of Indiana, 15-8S-15W.	4	1				60	Tar Springs Cypress sand	2,017–2,026 2,370–2,440	Inman East	2,667
261	Henry R. Skiles and State of Indiana, 15-8S-15W.	5	1				192	Tar Springs and Cypress sand		Inman East	2,408
262	Henry R. Skiles and State of Indiana, 15-8S-15W.	6	1				75	Tar Springs and Waltersburg sand		Inman East	2,060
263	Henry R. Skiles and State of Indiana, 15-8S-15W.	7	1				54	Waltersburg sand, Tar Springs sand and Cypress sand	2,392–2,396	Inman East	2,402
264	Henry R. Skiles, 15-8S-15W	2	1				66	Ste. Genevieve	2,626–2,668	Inman East	2,667

TABLE 4.—(*Continued*)

Line Number	County, Farm Name, Location	No. of Wells	Type of Wells: Oil	Gas	Dry	Wild-cat	Initial Production	Producing Horizon	To Top, Ft.	Name of Field	Total Depth, Ft.
265	Henry R. Skiles, 15-8S-15N	3	1				45	McClosky	2,775–2,799	Inman East	2,842
266	Henry R. Skiles, 15-8S-15W	4	1				74	Aux Vases	2,638	Inman East	2,678
267	Henry R. Skiles, 15-8S-15W	5	1				200	Tar Springs and Waltersburg sand		Inman East	2,450
268	Henry R. Skiles, 15-8S-15W	6	1				190	Waltersburg sand Cypress sand	1,960–1,986 2,400–2,410	 Inman East	 2,851
269	Henry R. Skiles, 15-8S-15W	7	1				164	Cypress and Tar Springs sand	2,687 2,396 show	Inman East Inman East	2,711 2,673
270	Henry R. Skiles, 15-8S-15W	8	1				50	Cypress sand	2,666–2,673 show		
271	Henry R. Skiles, 15-8S-15W	9	1				438	Waltersburg and Tar Springs	2,057–2,065 S.O.	Inman East	2,067
272	Henry R. Skiles, 15-8S-15W	10	1				60	Cypress sand and Tar Springs			
273	Henry R. Skiles, 15-8S-15W	11	1				76	Waltersburg sand Tar Springs sand	1,950–1,975 2,044–2,057	Inman East Inman East	2,689 2,717
274	Henry R. Skiles, 15-8S-15W	12			1			Show oil, Tar Springs and Hardinsburg and Cypress sand	2,379–2,470	Inman East	2,695
275	Henry R. Skiles, 15-8S-15W	13	1				240	Cypress sand	2,394–2,408 S.O.	Inman East	2,488
276	Mrs. Edith Theobald, 22-8S-15W	1	1				168	Waltersburg sand	1,953–1,968	Inman East	1,974
277	Mrs. Edith Theobald, 22-8S-15W	2	1				60	Tar Springs sand	2,054–2,060 S.O.	Inman East	2,062
278	Mrs. Edith Theobald and State of Indiana, 22-8S-15W	1	1				36	Waltersburg sand	1,968–1,976	Inman East	1,980
	St. Joseph County										
279	Notre Dame University, 20-38N-4E	1			1	1		Show oil	1,013–1,016		1,045
	Spencer County										
280	P. L. Jochim, 3-4S-5W	1			1	1		Ste. Genevieve	972		1,220
281	J. Bettag, 25-4S-5W	1			1	1		Tar Springs McClosky	513 974–976		544
282	Paul Gogel, 25-4S-5W	1			1			Devonian	2,292	Santa Claus	2,502
283	D. R. Hanning, 2-5S-5W	1			1	1		Ste. Genevieve	922		1,133
284	Lester Martin, 36-7S-7W	2	1				10	Palestine	930	Rockport	936
285	Lulu B. Howard, 1-8S-7W	1			1			Renault	1,500	Enterprise	1,535
286	Ruth L. Stewart, 27-6S-5W	9			1			Ste. Genevieve	1,048	Grandview	1,048
287	Ruth L. Stewart, 28-6S-5W	10	1				10	Saturation	880–894	Grandview	895
288	Frank Baize, 27-6S-5W	1	1				9	P.C. sand	975	Grandview	1,060
289	Chris Smith, 32-6S-5W	1			1	1		Ste. Genevieve	1,075		1,210
290	Elva Stallings, 11-7S-6W	1			1			St. Louis	1,495	Rock Hill	1,506
291	Hall and Pattie, 29-7S-6W	2	1				7	Palestine	923–962	Rockport	962
292	Hall and Pattie, 29-7S-6W	3	1				15	Palestine	938–955.5	Rockport	955.5
293	Hall and Pattie, 29-7S-6W	4	1				8	Palestine	941–963	Rockport	974
294	Hall and Pattie, 29-7S-6W	6	1				10	Palestine	958–975	Rockport	975
							Cu. Ft.				
295	E. L. and Minnie B. Hayden, H. and W., 30-7S-6W	1		1			2,680,000			Rockport (Gas)	917

296	Maude Smith, 6-7S-7W.	2	1				Barrels 15	Waltersburg	1,027–1,047	Hatfield	1,051
297	Clyde and Flora Richards, 11-7S-7W.	2			1			Waltersburg	1,025–1,029	Richland	1,033
298	Hattie Mason and Ellen Baird, 26-7S-7W.	1			1			McClosky	1,700–1,704 and 1,719–1,730	Enterprise	1,730
299	W. S. Frank, Posey Frank and W. E. Niles, 36-7S-7W.	1			1		(Well deepened from 950 to 1570 ft.)	Cypress sand	1,415–1,422	Enterprise	620
	Sullivan County										
300	Wabash Valley Land and Cattle Company, Inc., 10-6N-10W.	1			1	1		Devonian	2,690		2,968
301	E. Phegley, 14-6N-10W.	1			1	1		Devonian show oil	2,635		2,845
302	Clem Wisenor, 8-8N-10W.	1			1			Ste. Genevieve	1,152	Dodds Bridge	1,255
303	Raley-Harmon Comm., 33-8N-10W	1			1	1		Devonian	2,629		2,834
304	Jess A. Dix, et al., 35-8N-10W.	1		1			Cu. Ft. 50,000	Golconda	322–325	Sullivan	1,818
305	F. B. Mahan, 9-9N-8W.	1			1	1		Devonian	1,978		2,241
306	Alva N. Taylor, 8-9N-9W.	1			1	1		Devonian	2,228		2,480
307	John C. Gross, 3-9N-10W.	1			1	1		Devonian	2,342		2,388
	Tippecanoe County										
308	Arthur Wolfe, 10-24N-3W.	1			1	1		Trenton	895		906
	Vanderburgh County										
309	Tony Seib, et al., 22-5S-11W.	1			1	1		Ste. Genevieve	2,448		2,544
310	Albert E. Macke, 25-5S-11W.	1			1	1		Ste. Genevieve	2,395		2,562
311	Herman Barrett and J. Wathen, Comm., 1-7S-10W.	1			1	1		McClosky	2,240–2,248		2,370
	Wabash County										
312	Millard F. and Ida M. Votaw, Godfrey Reserve, 12-27N-5E.	1			1	1					890
313	P. Peebles, 33-27N-6E.	1			1	1		Trenton	966		987
314	G. C. Harwood, 19-27N-8E.	1			1	1		Trenton	949		985
315	E. W. Karns, 1-28N-6E.	1			1	1		Trenton	1,067		1,106
316	H. F. Shultz, 24-28N-6E.	1			1	1					1,067
	Warrick County										
317	Frank Schraer, 34-4S-6W.	1			1			Ste. Genevieve	1,175 ?		1,263
318	Eula Grimwood, 26-4S-9W.	1			1	1		McClosky	1,913–1,917 water		1,917
319	Bondholders Protective Committee of Verona Coal Co., 8-5S-7W.	1			1	1		St. Louis	1,766		1,775
320	Thomas H. Helms, 23-6S-8W.	1			1	1		McClosky	1,753–1,760 water		1,886
321	C. L. Hart, 27-5S-8W.	1			1	1		St. Louis	1,857		1,913
	Wells County										
322	Ellis Williams, 30-25N-13E.	1			1			Trenton	991	Old Trenton	1,044
323	Fred G. Turner, Fee, 32-25N-13E.	3			1		Barrels 3.5	Trenton	973	Old Trenton	1,034
324	Fred G. Turner, Fee, 32-25N-13E.	4			1			Trenton	973	Old Trenton	1,040
325	Fred G. Turner, Fee, 32-25N-13E.	5			1			Trenton	982	Old Trenton	1,073
326	R. Aschliman, 7-27N-13E.	1			1			Trenton	1,142	Old Trenton	1,164
327	W. and N. Graham, 8-27N-13E.	1			1	1					1,150
328	B. T. James, 19-27N-13E.	1			1			Trenton	1,136–1,148, 1,164–1,184 S.O.	Old Trenton	1,185
329	L. E. Spehlger, 31-27N-13E.	1			1			Trenton	1,135	Old Trenton	1,283
330	W. N. Rupright Heirs, 31-28N-13E	1			1	1					1,297
	White County										
331	Eddie St. Pierre, 27-27N-6W.	2			1		Comp. as water well				135

Oil and Gas Fields of Kansas during 1944

By Frank M. Brooks*

Endeavoring to meet the requirements of more oil created by the war effort, the oil industry of Kansas in 1944 maintained a level of exploratory and development work well above the average of previous years. During the year, 1866 test wells were drilled, of which 838 were completed as new oil wells, 89 as new gas wells and 939 as dry holes. These figures compare with 895 new oil wells, 32 new gas wells and 834 dry holes for a total of 1761 tests in 1943. Thus, there was a marked decrease in the number of new oil wells, and an increase in the new gas wells and dry holes. The total daily initial potential of production discovered by the successful wells amounted to 494,689 bbl. of oil as compared with 736,297 bbl. in 1943. The increase in unsuccessful tests and decrease in the daily initial potential of production has caused considerable comment and speculation among the oil operators of the state. This tends to confirm the fact that each year it is becoming harder to find the remaining oil fields.

The total number of wildcats drilled in Kansas was 651 in 1944, including the so-called "extension wildcats" (more than ½ to 1 mile from known production). Of this number, 410 are classified as "rank wildcats," being more than one mile from production. The total of 651 compares with the total of 577 for 1943, showing an increase in wildcat drilling of 74 test wells. Of these tests, 81 were successful in finding new oil fields or substantially extending known areas of production, and 20 either found new gas pools or extended old ones. The ratio of dry holes to producing wells among the "rank" wildcats was approximately 10 to 1 (372 dry and 38 successful). This compares with a ratio of 10 to 1 in 1943, 11 to 1 in 1942, and 6 to 1 in 1941.

A compilation of the results obtained by 34 active companies, including all of the major companies, reveals that their efforts accounted for 286 rank wildcat wells, of which 37 found oil or gas, making a dry-hole percentage of 87. Approximately 55 per cent of all tests (pool and wildcat) were failures.

The Kansas Nomenclature Committee of the Kansas Geological Society named and classified 43 new oil fields and 8 new gas fields during the year. The discovery wells of the new oil fields had a total initial potential of 18,358 bbl. for a per well average of 427 bbl. The average initial potential per well in 1942 and 1943 was 894 and 419 bbl., respectively.

With nearly all wells producing at their economic capacity, the total production for Kansas during 1944 totaled 101,896,704 bbl., which compares with total runs of 107,709,679 bbl. in 1943. Production of natural gas during 1944 reached a new high record of 135 billion cubic feet. This compares with 122 billion cubic feet for 1943, and 98½ billion cubic feet for 1942. The large Hugoton field of Southwestern Kansas accounted for about half of the total gas produced.

Highlights of the Year

Although 51 new fields were found in the state during 1944, it is apparent that the

Manuscript received at the office of the Institute March 26, 1945.

* Bridgeport Oil Company, Inc., Wichita, Kansas.

TABLE I.—*New Pools Discovered in Kansas in* 1944

Line Number	County, Field and Location	Operator and Fee	Geologic Formation	Depth, Ft.	Month	Initial Production[a]
	Barber					
1	Skinner, NW., 17-31S-14W	Huber No. 1 Skinner	Viola	4,356–4,374	Apr.	57 Gas
2	Skinner, S., 32-31S-14W	Dickey No. 1 Mills	Douglas sd.	4,023–4,025	Mar.	3 Gas
3	Marjorie, 31-30S-13W	Phillips No. 1 Marjorie	Viola	4,511–4,519	June	47 Gas
4	Hargis, 3-31S-14W	Dickey No. 1 Hargis	Viola	4,394–4,431	Sept.	4 Gas
5	Marjorie, E., 32-30S-13W	Huber No. 1 Gant	Viola	4,617–4,621	Sept.	34½ Gas
	Barton					
6	Feltes, N., 2-16S-12W	Winkler & Koch No. 1 Schauf "B"	Arbuckle	3,338–3,344	Feb.	40
7	Reif, 30-16S-12W	Mineral Products No. 1 Reif	Arbuckle	3,399–3,403	Feb.	250
8	St. Peter, 5-19S-11W	Ash No. 1 Schlochtermeire	Arbuckle	3,387–3,407	Apr.	586
9	Pawnee Rock, NE., 7-20S-15W	Stanolind No. 1 Unruh	Arbuckle	3,753–3,755	May	1,270
10	Peach, 25-16S-14W	Phillips No. 1 Chal	Arbuckle	3,404–3,442	July	140
11	Pritchard, 34-20S-14W	Texas No. 1 Pritchard	Arbuckle	3,542–3,545	May	1,526
12	Workman, 33-20S-12W	Vickers No. 1 Workman	Arbuckle	3,408–3,455	Oct.	221
	Brown					
13	Livingood, 3-1S-15E	Tomer No. 1 Livingood	Hunton	2,578–2,590	Dec.	85
	Ellis					
14	Pleasant, 2-14S-20W	Sunray No. 1 Orth	Basal sand	3,848–3,852	Sept.	563
15	Younger, 6-14S-17W	Sunray No. 1 Younger "B"	Arbuckle	3,538–3,583	Oct.	50
16	Schmeidler, 28-12S-17W	Alexander No. 1 Schmeidler	Arbuckle	3,625–3,647	Dec.	88
	Ellsworth					
17	Bloomer, E., 18-17S-10W	Ingling No. 1 Murray	Arbuckle	3,310–3,332	July	35
18	Vacek, 32-15S-10W	Cities Service No. 1 Vacek	Arbuckle	3,316–3,320	May	101
	Graham					
19	Alda, 15-7S-22W	Skelly No. 1 Davis	Lans.-K.C.	3,520–3,524	Nov.	518
	Greenwood					
20	Petterson, 19-27S-11E	Wiedeman No. 1 Petterson	Arbuckle	2,405–2,406	Aug.	25
	Harvey					
21	Stucky, S., 10-23S-3W	Rockhill No. 1 Woods	Mississippi	3,268–3,278	Mar.	2 Gas
	Kiowa					
22	Alford, 14-30S-19W	Lion No. 1 Alford	Mississippi	5,035–5,053	Sept.	3 Gas
	Leavenworth					
23	Lawrence, N., 22-12S-20E	Huber No. 1 Mohler	Squirrel sd.	700–711	Nov.	627,000 Gas
	McPherson					
24	Jenday, 1-19S-2W	Derby No. 1 Day	Mississippi	2,984–3,006	July	100
25	Gypsum Creek, 4-17S-1W	Williams & Morine No. 1 Henne	Mississippi	2,621–2,635	Nov.	75
26	Jenday, S., 7-19S-1W	Bay No. 1 Myers	Mississippi	2,952–2,957	Sept.	100
	Ness					
27	Arnold, 22-16S-25W	Sohio No. 1 Frevale	Mississippi	4,529–4,550	Jan.	142
28	Kansada, 23-17S-26W	Skelly No. 1 Norton	Mississippi	4,450–4,461	July	130
	Pawnee					
29	Pawnee Rock, S., 25-20S-16W	Aylward No. 1 Bixby	Arbuckle	3,820–3,830	Mar.	362
	Pratt					
30	Coats, 24-29S-14W	Lion No. 1 Andrew	Simpson	4,395–4,403	Apr.	731
31	Ludwick, 4-29S-13W	Skelly No. 1 Shaw	Simpson	4,489–4,516	Aug.	142
32	Shriver, 33-29S-14W	Skelly No. 1 Shriver	Simpson	4,557–4,564	Oct.	344
	Reno					
33	Lerado, SW., 21-26S-9W	Phillips No. 1 Wyman	Viola	4,177–4,188	Feb.	93
	Rice					
34	Orth, W., 21-18S-10W	Ohio No. 1 Bieberle	Arbuckle	3,233–3,270	May	88
35	Doran, W., 14-19S-10W	Robertson No. 1 Helmke	Arbuckle	3,265–3,278	June	136
36	Smyres, N., 23-19S-6W	Nelson No. 1 Allison	Mississippi	3,342–3,384	Dec.	15
	Rooks					
37	Hobart, 33-8S-18W	Continental No. 1 Welch	Lans.-K.C.	3,213–3,225	Feb.	708
38	Zurich townsite, 27-9S-19W	Cities Service No. 1 Sikes	Arbuckle	3,644–3,650	Feb.	1,326
	Russell					
39	Beisel, 15-14S-12W	Bridgeport No. 1 Beisel	Arbuckle	3,266–3,284	Apr.	81
40	Claussen, 27-12S-14W	Davis No. 1 Claussen	Lans.-K.C.	2,854–2,861	May	9
	Sedgwick					
41	Clearwater, 22-29S-2W	Branine & Holl No. 1 Sautter	Kans. City	3,025–3,036	Sept.	207
	Sheridan					
42	Adell, 11-6S-27W	Continental No. 1 Cramer	Lans.-K.C.	3,758–3,762	May	840
	Stafford					
43	Richland, 27-24S-14W	Atlantic No. 1 Neill	Arbuckle	4,225–4,240	Feb.	221
44	Cadman, 4-25S-13W	Faulkner No. 1 Cadman	Viola	4,068–4,072	Aug.	25
45	McCandless, 30-25S-13W	Atlantic No. 1 McCandless	Simpson	4,251–4,267	Apr.	734
46	Ranson, 7-24S-11W	Magnolia No. 1 Ranson	Viola	3,783–3,785	May	2,856
47	Rattlesnake, W., 11-24S-14W	British-American No. 1 Koelsch	Lans.-K.C.	3,759–3,766	May	254
48	St. John townsite, 33-23S-13W	Stanolind No. 1 Delker	Arbuckle	3,919–3,924	June	2,359
49	Brock, 12-23S-12W	Phillips No. 1 Brock	Arbuckle	3,680–3,684	Nov.	330
	Sumner					
50	Zyba, SW., 22-30S-1W	Sullivan No. 1 Nixon	Simpson	3,917–3,929	Aug.	210
	Trego					
51	Ellis, NW., 26-12S-21W	Barnett No. 1 Cotton	Arbuckle	3,925–3,926	Mar.	242

[a] The word Gas indicates that the figure represents millions of cubic feet of gas; all other figures in this column indicate barrels of oil.

future reserves have not been materially increased. The majority of the new fields seem to be of minor importance. Realizing that it is impossible to estimate the future size or production of any field in Kansas with any accuracy, it appears that less

TABLE 2.—*Results of Drilling in Western Kansas Based on Type of Exploration Method*

Method	Production	Dry	Total	Percentage Productive
Subsurface	24	132	156	15
Seismograph	8	53	61	13
Core drill	9	29	38	24
Surface	0	5	5	0
Subsurface and seismograph	2	5	7	28
Subsurface and core drill	2	5	7	28
Surface and subsurface	0	2	2	0
Seismograph and core drill	0	4	4	0
Seismograph and surface	0	1	1	0
Surface and core drill	0	2	2	0
Gravimeter	0	1	1	0
Chance	12	129	141	8
Show in near-by well	2	1	3	66
Grand total	59	369	428	14

than four of the new fields hold much promise of contributing greatly to the oil reserves of the state. The following data summarize the important happenings of the year:

Barber County witnessed an increase in activity over the previous year, most of the successful finds being new gas reservoirs. Five new gas fields were found, four of which produce from the Viola (Maquoketa) and one from the Douglas sand. This development has indicated a considerable area as favorable for exploration and promises to become an important factor in the state's gas reserves.

In *Barton County* important new production was obtained by persistent drilling in known producing areas. The county tied for first place in number of new fields found during the year, with a total of seven. One of these, the Pawnee Rock, Northeast, might be classified as an extension. The Pritchard field is considered by many to be the outstanding "find" of 1944 in the state. At the close of the year seven wells had been completed, averaging a little more than 1000 bbl. daily.

TABLE 3.—*Production of Crude Oil in Kansas for* 1944

Month	Total Number of Wells	Number of Prorated Wells	Daily Average per Prorated Well	Total Runs
January	23,023	6,351	43.8	8,624,944
February	23,048	6,377	44.5	8,243,366
March	23,083	6,018	46.6	8,695,376
April	23,107	6,438	42.0	8,118,390
May	23,146	6,366	44.8	8,846,904
June	23,204	6,411	44.8	8,620,140
July	23,219	6,406	42.2	8,370,620
August	23,274	6,462	43.2	8,669,367
September	23,288	6,533	43.8	8,598,840
October	23,316	6,558	41.6	8,463,000
November	23,325	6,565	42.3	8,334,750
December	23,357	6,558	40.8	8,311,007
Total production				101,896,704

Brown County.—A new county was added to the list of those producing oil in Kansas when a Hunton oil well was completed in Brown County. The initial production was small and the character of the oil similar to that found across the state line in Nebraska. This find focused the attention of many operators toward northeast Kansas and will stimulate interest in the area.

TABLE 4.—*Production in Representative Counties of Eastern Kansas during* 1944

County	Number of Producing Wells	Production, Bbl.
Butler	2,634	4,701,653
Coffey	30	15,330
Cowley	687	2,631,846
Dickinson	4	31,799
Elk	224	188,366
Greenwood	2,381	3,631,760
Lyon	110	174,585
Marion	204	841,649
Woodson	257	214,557

Kiowa County came in for its share of publicity and attention through the discovery of Mississippian gas. No additional

TABLE 5.—*Producing Oil and Gas Fields in Western Kansas in 1944*

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
	Oil Pools of Barber County								
				Barrels					
1	Bear Creek, 30-31S-15W	1942	40	719	3,269	1	Douglas	4,235	18
2	Deerhead, 22-32S-15W	1943	80	31,196	35,546	2	Viola	4,950	9
3	Lake City, 7-31S-13W	1937	160	34,342	147,742	2 1	Simpson Arbuckle	4,530 4,607	12 4
4	Medicine Lodge, 13-33S-13W	1937	80	None	45,700	2	Misener	4,845	10
5	Skinner, 29-31S-14W	1943	120	20,332	20,332	3	Viola	4,626	20
6	Sun City, 35-30S-15W	1941	280	199,702	310,952	7	Lans.-K.C.	4,344	2
7	Turkey Creek, 20-30S-15W	1943	40	8,588	8,588	1	Pen. sand	4,430	26
8	Whelan, 32-31S-11W	1934	700	239,115	1,130,465	19	Elgin "Chat"	4,355	27
	Gas Pools of Barber County								
				Thousands Cu. Ft.					
9	Aetna, 13-34S-15W	1935	80	34,000	34,000	2	Mis. lime	4,816	14
10	Deerhead, 26-32S-15W	1942	280	None	None	3	Viola	4,931	9
11	Hargis, 3-31S-14W	1944	40	None	None	1	Viola	4,394	37
12	Marjorie, 31-30S-13W	1944	40	None	None	1	Viola	4,511	8
13	Marjorie, E., 32-30S-13W	1944	40	None	None	1	Viola	4,617	4
				Millions Cu. Ft.					
14	Medicine Lodge, 13-33S-13W	1927	6,000	14,356	89,177	36	"Chat"	4,455	93
15	Skinner, NW., 17-31S-14W	1944	40	None	None	1	Viola	4,356	18
16	Skinner, S., 32-31S-14W	1944	40	None	None	1	Douglas sand	4,023	2
	Oil Pools of Barton County								
				Barrels					
17	Ainsworth, 26-16S-13W	1936	5,000	554,831	3,738,501	81	Shawnee Lans.-K.C. Arbuckle	2,925 3,250 3,390	26 10 4
18	Ainsworth, SE., 11-17S-13W	1943	80	13,701	13,701	2	Arbuckle	3,358	3
19	Albert, 30-18S-15W	1935	1,600	131,067	1,099,227	17	Reagan	3,601	3
20	Ames, 22-18S-11W	1943	280	58,671	63,971	7	Lans.-K.C.-Sooy Arbuckle	3,042 3,325	7 10
21	Bahr, 26-18S-15W	1943	40	8,709	11,568	1	Reagan	3,495	7
22	Barrett, 36-16S-14W	1943	120	5,302	24,652	3	Arbuckle	3,463	2
23	Beaver, 16-16S-12W	1934	1,200	198,424	1,825,124	24	Oread Arbuckle Reagan	2,885 3,348 3,335	5 3 2
24	Beaver, NW., 6-16S-12W	1942	80	15,084	32,584	1 1	Shawnee Lans.-K.C.	2,876 3,066	5 12
25	Beaver, N., 4-16S-12W	1937	160	14,390	266,290	3	Arbuckle	3,316	10
26	Bird, 33-18S-15W	1940	40	2,649	14,899	1	Reagan	3,508	12
27	Bloomer, 36-17S-11W	1936	5,000	4,613,911	18,708,761	262	Lans.-K.C. Arbuckle	3,044 3,257	17 8
28	Boyd, 4-18S-14W	1939	640	119,264	119,953	16	Arbuckle	3,438	12
29	Breford, SW., 23-17S-11W	1942	40	4,185	13,435	1	Arbuckle	3,299	3
30	Davidson, 4-16S-11W	1928	300	37,138	230,288	9	Lans.-K.C. Sooy Arbuckle	3,016 3,317 3,314	4 10 9
31	Eberhardt, 14-19S-11W	1935	160	24,518	240,968	4	Arbuckle	3,311	3
32	Ellinwood, N., 33-19S-11W	1937	80	4,158	59,708	1	Arbuckle	3,328	8
33	Eveleigh, 11-18S-14W	1943	200	41,213	41,913	4 1	Arbuckle Pre-Cambrian	3,339 3,311	7 21
34	Feist, 29-18S-11W	1936	40	2,673	56,623	1	Pen. Cong.	3,430	3
35	Feltes, 14-16S-12W	1939	Now part of Kraft-Prusa	348,684	1,022,984		Lans.-K.C. Arbuckle	3,222 3,350	3 6
36	Feltes, N., 2-16S-12W	1944	40	378	378	1	Arbuckle	3,338	7
37	Hagan, 20-20S-11W	1938	160	35,450	142,850	4	Arbuckle	3,323	4
38	Hammer, 35-19S-12W	1940	40	776	11,976	1	Arbuckle	3,348	8
39	Harrison, 18-20S-13W	1942	40	727	1,427	1	Arbuckle	3,498	
40	Heizer, 16-19S-14W	1935	40	None	28,400	1	Lans.-K.C.	3,228	2
41	Hiss, 31-20S-13W	1936	200	26,963	414,763	5	Lans.-K.C.	3,270	5
42	Hoisington, 21-17S-13W	1938	160	26,602	167,502	1 2	Lans.-K.C. Arbuckle	3,222 3,440	8 4
43	Kowalsky, 32-20S-11W	1941	Abandoned		2,540	1	Arbuckle	3,378	7

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
44	Kraft-Prusa, 10-17S-11W	1937	17,000	4,154,812	14,030,312	338	Shawnee Lans.-K.C. Gorham Arbuckle Reagan	2,885 3,160 3,335 3,281 3,310	30 175 6 8 8
45	Lanterman, 15-19S-11W	1935	300	95,888	642,988	11	Lans.-K.C. Arbuckle	3,109 3,332	4 3
46	Merten, 10-19S-15W	1942	360	35,613	53,863	9	Reagan	3,551	6
47	Millard, 29-16S-14W	1943	40	3,402	3,402	1	Arbuckle	3,462	7
48	Mue Tam, 35-20S-11W	1942	40	3,732	14,782	1	Arbuckle	3,312	10
49	Odin, 10-17S-12W	1941	40	2,240	21,440	1	Arbuckle	3,340	2
50	Pawnee Rock, E., 17-20S-15W	1941	40	None	11,400	1	Arbuckle	3,814	5
51	Pawnee Rock, NE., 7-20S-15W	1944	120	11,468	11,468	3	Arbuckle	3,753	2
52	Peach, 25-16S-14W	1944	40	2,053	2,053	1	Arbuckle	3,404	10
53	Pritchard, 34-20S-14W	1944	240	23,565	23,565	6	Arbuckle	3,542	3
54	Reif, 30-16S-12W	1944	80	9,054	9,054	1 1	Lans.-K.C. Arbuckle	3,253 3,399	8 4
55	Rick, 1-19S-11W	1936	400	31,836	438,086	8	Lans.-K.C. Arbuckle	3,106 3,350	10 5
56	Roesler, 14-18S-11W	1943	40	7,033	13,233	1	Arbuckle	3,291	7
57	Silica, 12-20S-11W	1931	32,000	7,214,835	61,119,835	765	Lans.-K.C. Arbuckle	2,955 3,328	7 5
58	St. Peter, 5-19S-11W	1944	40	7,808	7,808	1	Arbuckle	3,387	3
59	Workman, 33-20S-12W	1944	40	1,274	1,274	1	Arbuckle	3,408	
	OIL POOL OF CLARK COUNTY								
60	Morrison, 17-32S-21W	1936	160	3,273	144,153	2	Viola	6,467	8
	GAS POOL OF EDWARDS COUNTY								
				THOUSANDS CU. FT.					
61	McCarty, 31-25S-17W	1929	160	762,957	920,957	1	Sooy	4,545	10
	OIL AND GAS POOLS OF ELLIS COUNTY								
				BARRELS					
62	Beeching, 34-15S-16W	1943	240	55,645	63,645	6	Lans.-K.C.	3,156	4
63	Bemis-Shutts, 16-11S-17W	1935	13,000	6,233,070	32,542,190	463	Arbuckle	3,380	11
64	Bemis, S., 2-12S-17W	1938	40	10,870	57,920	1	Arbuckle	3,592	11
65	Blue Hill, 14-12S-16W	1937	700	127,545	859,945	17	Topeka Lans.-K.C. Arbuckle	3,030 3,072 3,360	5 33 6
66	Burnett, 1-11S-18W	1937	5,000	3,759,535	18,719,185	208	Lans.-K.C. Arbuckle	3,093 3,570	8 4
67	Catherine, 3-13S-17W	1936	160	1,782	139,432	1	Lans.-K.C.	3,262	24
68	Ellis, 31-12S-20W	1942	700	164,255	224,005	13	Arbuckle	3,832	8
69	Emmeram, 4-13S-16W	1937	160	19,339	157,789	4	Lans.-K.C.	3,262	7
70	Haller, 10-11S-18W	1936	40	1,678	20,028	1	Topeka	3,045	9
71	Herzog, 30-13S-16W	1940	160	47,300	199,750	4	Arbuckle	3,450	8
72	High Spot, 28-12S-16W	1941	40	Abandoned		1	Arbuckle	3,620	6
73	Koblitz, 23-12S-18W	1937	800	83,857	390,557	9	Arbuckle	3,694	4
74	Kraus, 22-14S-19W	1936	100	3,625	72,225	1	Sooy	3,735	5
75	Kraus, NW., 17-14S-19W	1942	40	718	2,018	1	Gorham	3,798	4
76	Leiker, 14-15S-18W	1943	80	16,468	21,418	2	Lans.-K.C. Arbuckle	3,292	4
77	Marshall, 36-11S-18W	1936	Now part of Bemis-Shutts				Arbuckle	3,638	12
78	Penny Wann, 13-15S-20W	1936	80	10,961	62,241	2	Reagan	3,653	3
79	Pleasant, 2-14S-20W	1944	120	7,024	7,024	3	Arbuckle	3,848	4
80	Richards, 5-11S-18W	1938	120	4,586	106,786	3	Lans.-K.C.	3,332	41
81	Riverview, 19-11S-18W	1943	560	206,136	222,606	14	Arbuckle	3,610	9
82	Ruder, 17-15S-18W	1935	700	36,685	821,985	9 2	Lans.-K.C. Arbuckle	3,422 3,572	18 10
83	Schmeidler, 28-12S-17W	1944	40	None	None	1	Arbuckle	3,625	22
84	Solomon, 28-11S-19W	1936	160	None	104,600	2	Arbuckle	3,629	3
85	Sugar Loaf, 17-13S-17W	1941	80	34,000	100,900	2	Arbuckle	3,645	9
86	Sugar Loaf, SE., 28-13S-17W	1941	40	5,810	25,810	1	Lans.-K.C.	3,312	8
87	Toulon, 3-14S-17W	1935	200	24,959	241,959	6	Lans.-K.C. Arbuckle	3,298 3,512	5 45
88	Ubert, 12-13S-18W	1936	160	16,670	209,020	3	Arbuckle	3,707	7
89	Walters, 2-12S-18W	1936	1,400	370,850	2,840,100	37	Topeka Arbuckle	3,160 3,619	5 8
90	Younger, 6-14S-17W	1944	40	1,220	1,220	1	Arbuckle	3,538	45

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
	OIL POOLS OF ELLSWORTH COUNTY								
				BARRELS					
91	Bloomer, E., 18-17S-10W	1944	40	920	920	1	Arbuckle	3,310	22
92	Breford, 7-17S-10W	1932	Now part of Bloomer				Lans.-K.C. Arbuckle	3,140 3,368	12 27
93	Heiken, 25-17S-10W	1930	160	3,080	35,980	2	Arbuckle	3,269	2
94	Heiken, N., 24-17S-10W	1942	120	17,705	50,480	3	Arbuckle	3,212	2
95	Lorraine, 13-17S-9W	1934	5,500	278,800	9,415,200	74	Lans.-K.C. Arbuckle	3,060 3,200	40 5
96	Stoltenberg, 22-16S-10W	1931	8,200	2,031,920	12,730,820	198	Lans.-K.C. Arbuckle	3,333	14
97	Stoltenberg, SW., 20-16S-10W	1940	320	22,580	80,180	4	Arbuckle	3,349	7
98	Vacek, 32-15S-10W	1944	40	1,977	1,977	1	Arbuckle	3,316	4
99	Wilkins, 13-17S-10W	1934	3,600	804,120	3,938,720	71	Arbuckle	3,260	20
100	Wilkins, SE., 32-17S-9W	1942	200	50,410	123,910	5	Arbuckle	3,220	9
	OIL POOL OF FINNEY COUNTY								
101	Nunn, 27-21S-34W	1938	800	78,760	252,260	7	Mississippi	4,654	10
	OIL POOL OF FORD COUNTY								
102	Pleasant Valley, 34-27S-21W	1942	40	None	3,580	1	Mississippi	4,892	16
	OIL POOLS OF GRAHAM COUNTY								
103	Alda, 15-7S-22W	1944	40	None	None	1	Lans.-K.C.	3,520	4
104	Gettysburg, 7-8S-23W	1941	40	3,185	18,210	1	Lans.-K.C.	3,745	30
105	Morel, 15-9S-21W	1938	4,960	846,820	1,912,820	55	Arbuckle	3,718	12
106	Penokee, 11-8S-24W	1940	40	3,850	41,000	1	Lans.-K.C.	3,750	6
	OIL AND GAS POOLS OF HARVEY COUNTY								
107	Burrton, NE., 9-23S-3W	1943	40	None	None	1	"Chat"	3,305	10
108	Halstead, 36-22S-2W	1929	1,200	62,470	1,526,920	19	"Chat"	3,005	30
109	Hollow-Nikkel, 30-22S-3W	1931	1,500	239,640	19,673,340	61	"Chat" Hunton Simpson	3,195 3,507 3,500	13 5 14
110	Sperling, 23-22S-2W	1935	500	33,000	474,200	5	Hunton	3,279	16
111	Stucky, 3-23S-3W	1942	40	300	750	1	Mississippi	3,224	14
				THOUSANDS CU. FT.					
112	Sperling, 23-22S-2W	1935		11,636	6,239,746	2	"Chat"	2,955	50
113	Stucky, S., 10-23S-3W	1944	40	None	None	1	Mississippi	3,268	10
	OIL POOL OF KEARNY COUNTY								
				BARRELS					
114	Patterson, 23-22S-38W	1941	120	32,755	115,855	3	Patterson sd.	4,740	4
	OIL AND GAS POOLS OF KINGMAN COUNTY								
115	Cunningham, 30-27S-10W	1931	1,400	699,810	4,829,960	117	Lans.-K.C. Viola	3,390 3,925	74 33
				MILLIONS CU. FT.					
116	Cunningham, 30-27S-10W	1931	1,400	5,709 1,172		35 4	Viola Arbuckle	3,926 4,093	24 77
	GAS POOL OF KIOWA COUNTY								
117	Alford, 14-30S-19W	1944	40	None	None	1	Mississippi	5,035	18

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
	OIL POOLS OF MCPHERSON COUNTY								
				BARRELS					
118	Bitikofer, 1-20S-1W	1940	180	39,930	92,830	5	"Chat"	2,885	24
119	Bornholdt, 30-20S-5W	1937	5,000	1,508,085	7,640,185	146	"Chat"	3,292	43
120	Canton, N., 26-18S-1W	1936	280	47,440	149,740	7	"Chat"	2,803	29
121	Chindberg, 18-19S-2W	1929	700	55,960	1,496,410	25	Lans.-K.C. "Chat"	2,363 3,007	19 14
122	Crowther, 26-17S-1W	1942	900	285,720	482,870	19	"Chat"	2,778	12
123	Graber, 32-21S-1W	1934	2,800	354,180	7,899,430	2 130	Misener Hunton	3,323 3,274	3 24
124	Gypsum Creek, 4-17S-1W	1944	40	210	210	1	"Chat"	2,621	14
125	Henne, 21-17S-1W	1940	800	265,290	687,190	21	"Chat"	2,658	4
126	Jenday, 1-19S-2W	1944	160	10,266	10,266	4	"Chat"	2,984	22
127	Jenday, S., 7-19S-1W	1944	80	7,047	7,047	2	"Chat"	2,952	5
128	Johnson, 35-19S-3W	1932	1,200	102,070	2,908,570	15	"Chat"	3,032	14
129	Lindsborg, 8-17S-3W	1938	6,500	942,930	2,120,130	109	Viola Simpson	3,352 3,360	21 11
130	McPherson, 29-18S-2W	1926	2,000	38,040	1,055,270	21	"Chat" Viola	2,967 3,140	11 6
131	Paden, 10-18S-1W	1943	800	135,490	136,110	15	"Chat"	2,752	18
132	Ritz-Canton, 1-21S-2W	1929	1,300	850,250	37,861,650	217	Lans.-K.C. "Chat" Viola Simpson	2,360 2,935 3,412 3,440	39 31 2 4
133	Roxbury, 18-17S-1W	1938	2,500	345,980	1,733,660	38	"Chat"	2,684	5
134	Roxbury, S., 30-17S-1W	1942	160	45,160	128,730	4	"Chat"	2,658	7
135	Roxbury, SE., 20-17S-1W	1943	40	3,625	5,415	1	"Chat"	2,665	9
136	Voshell, 9-21S-3W	1929	3,500	620,000	25,324,000	87	"Chat" Viola Simpson Arbuckle	3,095 3,301 3,322 3,394	15 3 3 10
	OIL POOLS OF NESS COUNTY								
				BARRELS					
137	Aldrich, 7-18S-25W	1929	4,000	140,265	793,265	17	Mis. lime	4,428	2
138	Arnold, 22-16S-25W	1944	80	11,350	11,350	2	Mis. lime	4,529	21
139	Kansada, 23-17S-26W	1944	40	732	732	1	Mis. lime	4,450	11
	OIL POOL OF NORTON COUNTY								
140	Hewitt, 11-4S-21W	1941	80	5,820	26,050	1	Lans.-K.C.	3,404	3
	OIL POOLS OF PAWNEE COUNTY								
141	Pawnee Rock, 13-20S-16W	1936	2,400	268,430	1,246,130	25	Arbuckle	3,825	16
142	Pawnee Rock, S., 25-20S-16W	1944	40	6,824	6,824	1	Arbuckle	3,820	10
143	Zook, 16-23S-16W	1941	80	None	7,450	2	Arbuckle	4,066	8
	OIL POOLS OF PHILLIPS COUNTY								
144	Bow Creek, 25-5S-18W	1939	40	3,450	29,630	1	Lans.-K.C.	3,111	53
145	Dayton, 36-2S-19W	1941	1,200	134,630	492,280	22	Lans.-K.C.	3,430	8
146	Dayton, N., 13-2S-19W	1943	240	55,445	73,245	6	Lans.-K.C.	3,406	16
147	Hansen, 14-5S-20W	1943	400	93,150	120,650	10	Lans.-K.C. Arbuckle	3,300 3,530	8 6
148	Ray, 32-5S-20W	1940	3,000	1,168,190	3,252,140	76	Arbuckle Reagan	3,575 3,540	6 13
	OIL AND GAS POOLS OF PRATT COUNTY								
149	Cairo, 7-28S-11W	1939	160	29,420	105,770	8	Viola	4,267	16
150	Carmi, 29-26S-12W	1942	3,500	2,491,060	3,028,960	1 86	Simpson Arbuckle	4,184 4,266	8 31
151	Chitwood, 23-28S-12W	1943	1,300	529,720	544,520	32	Viola Simpson Arbuckle	4,286 4,383 4,452	21 3 8

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
152	Coats, 24-29S-14W	1944	120	18,280	18,280	3	Simpson	4,395	8
153	Frisbie, 5-26S-13W	1943	160	36,970	55,620	4	Lans.-K.C.	3,947	8
154	Iuka, 11-27S-13W	1937	2,000	217,990	649,960	23 1	Simpson Arbuckle	4,292 4,354	7 5
155	Ludwick, 4-29S-13W	1944	40	4,215	4,215	1	Simpson	4,489	27
156	Shriver, 33-29S-14W	1944	40	3,612	3,612	1	Simpson	4,557	7
157	Stark, 18-26S-11W	1941	500	228,430	309,430	13	Viola	4,121	2
				THOUSANDS CU. FT.					
158	Cairo (gas), 7-28S-11W	1935	20,000	182,993	41,682,993	33	Viola	4,278	8
159	Chitwood (gas), 23-28S-12W	1943	1,300	1,853,222	1,853,222	10	Viola	4,286	21
	OIL AND GAS POOLS OF RENO COUNTY								
				BARRELS					
160	Abbyville, 24-24S-8W	1927	1,200	26,120	507,280	9	Lans.-K.C.	3,540	9
161	Buhler, 25-22S-5W	1938	500	35,900	486,000	8	Simpson	3,897	5
162	Burrton, 23-23S-4W	1931	5,000	1,517,770	38,430,970	376	"Chat" Hunton	3,266 3,583	42 6
163	Hilger, 16-26S-4W	1934	600	215,880	2,966,580	31	Viola	4,062	5
164	Hilger, N., 34-25S-4W	1943	480	121,110	134,110	12	Viola	4,099	3
165	Lerado, 11-26S-9W	1935	1,800	8,570	2,533,430	22	Viola	4,128	4
166	Lerado, SW., 21-26S-9W	1944	80	6,790	6,790	2	Viola	4,177	11
167	Morton, 17-24S-8W	1942	40	4,410	14,810	1	Lans.-K.C.	3,180	12
168	Peace Creek, 21-23S-10W	1941	12,000	1,609,250	6,245,950	132	Viola	3,773	3
169	Yoder, 34-24S-5W	1935	500	2,045	82,870	5	"Chat"	3,450	51
				MILLIONS CU. FT.					
170	Burrton (gas), 23-23S-4W	1930		2,465	58,913	52	"Chat"	3,298	70
171	Yoder (gas), 34-24S-5W	1936	800	469		4	"Chat"	3,402	50
	OIL AND GAS POOLS OF RICE COUNTY								
				BARRELS					
172	Bowman, 21-19S-10W	1936	250	51,850	190,200	5	Lans.-K.C. Arbuckle	3,032 3,272	10 5
173	Brandenstein, 10-19S-10W	1933	160	18,140	428,540	2	Lans.-K.C.	3,014	12
174	Bredfeldt, W., 12-18S-10W	1939	80	3,860	37,860	2	Arbuckle	3,260	8
175	Chase, 32-19S-9W	1931	8,000	3,664,400	37,318,100	394	Lans.-K.C. Arbuckle	2,942 3,246	12 10
176	Click, 3-18S-7W	1943	40	4,710	4,710	1	Sooy	3,182	5
177	Doran, 13-19S-10W	1936	300	60,975	289,900	8	Arbuckle	3,291	20
178	Doran, W., 14-19S-10W	1944	80	9,730	9,730	2	Arbuckle	3,265	13
179	Edwards, 3-18S-8W	1936	2,600	994,175	6,035,900	87	Arbuckle	3,278	5
180	Geneseo, 25-18S-8W	1934	5,600	2,249,575	14,844,500	195	Arbuckle	3,132	14
181	Haferman, 6-19S-9W	1936	800	84,140	749,600	1 9	Lans.-K.C. Arbuckle	2,810 3,192	10 24
182	Heinz, 8-18S-10W	1938	80	6,520	66,850	1 1	Lans.-K.C. Arbuckle	3,000 3,254	19 14
183	Karber, 7-19S-10W	1940	200	29,950	109,000	5	Arbuckle	3,343	7
184	Keller, 3-19S-9W	1943	40	9,700	13,750	1	Sooy	3,240	3
185	Lyons, 14-20S-8W	1939	40	None	11,550	1	Simpson	3,274	4
186	Orth, 27-18S-10W	1932	1,000	135,900	1,168,900	20	Shawnee Lans.-K.C. Pre-Cambrian	 2,915 3,240	 21 3
187	Orth, W., 21-18S-10W	1944	40	3,062	3,062	1	Arbuckle	3,233	37
188	Pioneer, 25-19S-10W	1942	40	8,900	25,000	2	Arbuckle	3,281	5
189	Ploog, 33-18S-9W	1930	500	31,650	1,396,850	8	Arbuckle	3,252	19
190	Ponce, 28-21S-7W	1936	40	2,875	39,150	1	Sooy	3,388	40
191	Raymond, 21-20S-10W	1929	1,200	638,250	8,413,350	64	Lans.-K.C. Arbuckle	3,130 3,330	10 21
192	Rickard, 22-18S-9W	1935	160	14,860	116,160	4	Arbuckle	3,324	41
193	Smyers, 36-19S-6W	1942	1,000	216,960	621,760	23	"Chat"	3,339	25
194	Volkland, 27-18S-9W	1943	300	98,895	105,670	7	Arbuckle	3,221	30
195	Welch, 2-21S-6W	1924	1,500	76,190	4,518,040	22	"Chat"	3,370	44
196	Welch, E., 1-21S-6W	1941	80	7,550	17,500	2	"Chat"	3,341	5
197	Welch, N., 23-20S-6W	1937	160	5,100	62,200	3	"Chat"	3,334	32
198	Wenke, 7-20S-10W	1935	500	97,900	708,800	10	Arbuckle	3,360	13
199	Wenke, W., 18-20S-10W	1938	80	18,265	99,650	2	Arbuckle	3,292	5
200	Wherry, 11-21S-7W	1933	7,000	332,940	9,280,390	119	Sooy	3,358	22
				MILLIONS CUBIC FEET					
201	Alden (gas), 22-21S-9W	1937	400	1,155	11,491	7	Misener	3,317	10
202	Lyons (gas), 35-19S-8W	1888	1,500	309	11,704	1 11	Simpson Arbuckle	3,290 3,277	7 10
203	Orth (gas), 27-18S-10W	1933	640	346		3	Lans.-K.C.	2,906	30

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
	OIL POOLS OF ROOKS COUNTY			BARRELS					
204	Barry, 11-9S-19W	1941	840	436,800	541,000	21	Lans.-K.C. Arbuckle	3,376 3,435	39 7
205	Baum, 10-10S-16W	1941	40	1,470	6,350	1	Lans.-K.C.	3,057	15
206	Dopita, 31-8S-17W	1934	500	50,900	335,450	9	Lans.-K.C. Arbuckle	3,212 3,409	5 10
207	Dorr, 20-9S-16W	1941	200	33,035	57,310	5	Lans.-K.C.	3,230	21
208	Erway, 2-10S-16W	1941	40	7,315	27,105	1	Lans.-K.C.	3,136	40
209	Faubion, 12-6S-18W	1936	80	1,980	48,860	1	Lans.-K.C.	3,128	22
210	Hobart, 33-8S-18W	1944	120	12,905	12,905	3	Lans.-K.C.	3,213	12
211	Kriley, 22-8S-18W	1943	40	1,550	2,680	1	Arbuckle	3,310	45
212	Kruse, 3-10S-16W	1928	40	None	10,335	1	Lans.-K.C.	3,115	6
213	Laton, 11-9S-16W	1927	1,300	280,265	2,416,565	89	Lans.-K.C.	3,228	33
214	Marcotte, 15-10S-20W	1943	280	50,185	50,185	7	Arbuckle	3,752	6
215	Palco, 5-10S-20W	1943	120	19,076	19,076	3	Arbuckle	3,824	19
216	Ray, SE., 9-6S-20W	1941	40	9,155	27,930	1	Reagan	3,600	6
217	Stockton, 35-7S-17W	1937	80	4,270	30,670	1	Lans.-K.C.	3,180	62
218	Webster, 21-8S-19W	1930	40	Abandoned	56,369	0	Arbuckle	3,434	1
219	Westhusin, 11-9S-17W	1936	700	108,410	776,110	15	Lans.-K.C.	3,231	11
220	Zurich, 26-10S-19W	1934	200	15,470	156,520	5	Lans.-K.C.	3,340	9
221	Zurich townsite, 27-9S-19W	1944	40	6,105	6,105	1	Arbuckle	3,644	6
	OIL AND GAS POOLS OF RUSH COUNTY								
222	Otis, 10-18S-16W	1934	1,200	282,960	2,515,735	25	Reagan	3,527	9
223	Winget, 15-16S-16W	1936	120	570	50,570	1	Lans.-K.C.	3,243	4
				MILLIONS CU. FT.					
224	Otis (gas), 11-18S-16W	1930	15,000	12,112	99,642	57	Reagan	3,507	2
	OIL POOLS OF RUSSELL COUNTY			BARRELS					
225	Atherton, 30-13S-14W	1935	1,900	153,725	1,615,000	7 28	Lans.-K.C. Arbuckle	3,008 3,284	47 5
226	Beisel, 15-14S-12W	1944	40	2,742	2,742	1	Arbuckle	3,266	18
227	Big Creek, 36-14S-15W	1935	3,200	413,295	4,406,645	80	Lans.-K.C. Gorham Arbuckle	2,908 3,152 3,171	42 5 5
228	Big Creek, E., 31-14S-14W	1938	700	104,090	496,910	12	Lans.-K.C. Arbuckle	3,180 3,149	15 4
229	Boxberger, 36-15S-15W	1935	160	6,880	175,630	3	Lans.-K.C.	3,147	4
230	Bunker Hill, 31-13S-12W	1935	160	None	74,825	3	Lans.-K.C.	2,965	16
231	Chegwidden, 29-15S-11W	1943	80	10,370	10,370	1 1	Lans.-K.C. Arbuckle	2,998 3,233	9 23
232	Claussen, 37-13S-14W	1944	40	591	591	1	Lans.-K.C.	2,854	7
233	Donovan, 10-15S-15W	1935	200	29,316	124,916	4	Lans.-K.C.	3,193	7
234	Driscoll, 30-15S-11W	1940	160	21,740	53,515	3	Arbuckle	3,255	5
235	Dubuque, 34-15S-12W	1935	300	49,920	333,720	2 4	Lans.-K.C. Arbuckle	3,275 3,330	3 5
236	Eichman, 24-15S-14W	1935	800	8,270	703,370	7	Arbuckle	3,316	10
237	Fairfield, 22-15S-13W	1938	40	10,065	22,715	1	Arbuckle	3,352	5
238	Fairport, 8-12S-15W	1923	3,600	809,120	17,074,320	145	Lans.-K.C. Gorham	2,950 3,211	12 5
239	Forest Hill, 29-15S-12W	1941	800	189,890	345,290	16	Arbuckle	3,320	3
240	Gideon, 8-15S-14W	1930	40	1,860	46,660	1	Sooy	3,266	7
241	Gorham, 5-14S-15W	1926	8,500	2,288,995	27,007,870	1 8 125 11 160	Tarkio Topeka Lans.-K.C. Arbuckle Reagan	2,525 2,765 3,027 3,289 3,299	25 15 30 4 1
242	Gustafson, 14-15S-12W	1941	160	19,260	53,080	2 1	Lans.-K.C. Arbuckle	3,050 3,344	12 5
243	Gustafson, NW., 15-15S-12W	1943	280	52,750	67,750	3 4	Lans.-K.C. Arbuckle	3,021 3,322	6 5
244	Hall-Gurney, 30-14S-13W	1931	25,000	3,706,050	22,670,000	542	Wabaunsee Topeka Lans.-K.C. Gorham Arbuckle Reagan Pre-Cambrian	 2,675 2,985 3,165 3,451 3,129 3,156	 12 15 4 3 1 25

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production 1944	Production Cumulative	Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
245	Janne, 24-15S-12W	1943	240	24,205	24,205	6	Arbuckle	3,319	10
246	Jerry, 4-15S-14W	1942	120	15,280	25,880	3	Lans.-K.C.	2,985	20
247	Lewis, 28-14S-12W	1940	40	847	11,130	1	Wabaunsee	2,317	12
248	Mahoney, 8-14S-12W	1940	120	3,480	39,860	2	Lans.-K.C.	2,977	3
249	Mohl, 18-14S-13W	1941	40	1,375	6,895	1	Reagan	3,253	5
250	Rusch, 29-14S-14W	1941	360	95,010	263,810	9	Lans.-K.C. Arbuckle	3,071 3,216	12 8
251	Russell, 22-13S-14W	1934	2,160	358,315	5,977,615	54	Lans.-K.C. Arbuckle	3,195 3,280	9 6
252	Russell, N., 15-13S-14W	1942	40	5,306	19,086	1	Lans.-K.C.	2,978	30
253	Sellens, 26-15S-13W	1929	1,300	230,515	3,196,140	34	Shawnee Lans.-K.C. Arbuckle	 3,088 3,352	 9 13
254	Strecker, 21-16S-14W	1943	80	9,090	14,140	2	Arbuckle	3,342	3
255	Trapp, 23-15S-14W	1939	32,000	9,183,025	55,299,300	4 137 762	Shawnee Lans.-K.C. Arbuckle	2,889 3,062 3,252	7 2 3
256	Vaughn, 17-14S-14W	1937	1,100	843,275	2,008,000	37	Lans.-K.C. Gorham Arbuckle	3,004 3,282 3,341	30 7 5
257	Williamson, 9-14S-14W	1936	1,840	436,195	669,365	46	Tarkio Lans.-K.C.	2,522 3,009	28 22
	OIL POOLS OF SALINE COUNTY								
258	Hunter, 20-16S-1W	1943	680	167,025	229,875	17	"Chat"	2,681	2
259	Olsson, 10-16S-3W	1929	80	13,760	15,810	2	Maquoketa	3,303	12
260	Pliny, 9-16S-1W	1943	40	2,867	7,017	1	Lans.-K.C.	1,989	9
261	Salina, 30-14S-2W	1943	80	10,640	17,740	2	Maquoketa	3,223	9
	OIL POOL OF SCOTT COUNTY								
262	Shallow Water, 15-20S-33W	1934	600	82,200	1,328,825	9	Miss. lime	4,670	16
	OIL POOLS OF SEDGWICK COUNTY								
				BARRELS					
263	Clearwater, 22-29S-2W	1944	40	3,245	3,245	1	Lans.-K.C.	3,025	11
264	Cross, 29-25S-1W	1929	160	4,180	60,080	2	Lans.-K.C.	2,690	40
265	Eastborough, 19-27S-2E	1929	1,000			31	"Chat" Viola	2,956 3,238	14 4
266	Goodrich, 16-25S-1E	1928	640	249,105	3,718,730	30	Lans.-K.C. "Chat" Misener	2,614 3,010 3,334	2 10 3
267	Greenwich, 14-26S-2E	1929	700	177,855	9,893,545	41	"Chat" Viola Simpson	2,885 3,321 3,350	3 5 4
268	Kuske, 24-25S-1E	1929	40	1,348	145,028	1	Sooy	3,013	2
269	Robbins, 20-28S-1E	1929	420	67,310	3,181,760	49	Mis. lime	3,090	12
270	Valley Center, 1-28S-1W	1928	1,500	218,750	21,038,750	58	Misener Viola	3,368 3,366	7 2
	OIL POOLS OF SHERIDAN COUNTY								
271	Adell, 11-6S-27W	1944	200	9,950	9,950	5	Lans.-K.C.	3,758	4
272	Studley, 23-8S-26W	1943	240	90,225	120,315	6	Lans.-K.C.	3,808	9
	OIL POOLS OF STAFFORD COUNTY								
				BARRELS					
273	Ahnert, 26-22S-13W	1941	40	7,700	23,400	1	Arbuckle	3,784	4
274	Bedford, 21-23S-12W	1940	850	137,045	841,720	21	Arbuckle	3,859	9
275	Brock, 12-23S-12W	1944	40	876	876	1	Arbuckle	3,680	4
276	Byron, 4-21S-12W	1943	40	4,665	6,665	1	Arbuckle	3,460	3
277	Cadman, 4-25S-13W	1944	40	2,042	2,042	1	Viola	4,068	4
278	Curtis, 6-22S-13W	1942	80	29,030	65,130	2	Arbuckle	3,693	7
279	Drach, 12-22S-13W	1937	2,200	517,240	1,245,900	43	Arbuckle	3,693	12
280	Farmington, 34-24S-15W	1943	440	152,935	177,310	1 10	Kinderhook sd. Arbuckle	4,261 4,417	15 16

TABLE 5.—(*Continued*)

Line Number	Pool and Location	Discovery Year	Area, Acres	Production		Number Wells Producing	Producing Zone	To Top, Feet	Thickness, Feet
				1944	Cumulative				
281	Fischer, 31-21S-12W	1938	120	38,545	212,795	4	Arbuckle	3,641	7
282	Gates, 27-21S-13W	1933	700	143,730	1,090,730	13	Arbuckle	3,679	39
283	Gates, S., 3-22S-13W	1943	40	1,370	1,805	1	Arbuckle	3,704	7
284	Grunder, 11-25S-15W	1943	40	4,340	7,890	1	Lans.-K.C.	3,945	15
285	Hazel, 21-21S-13W	1942	200	45,245	104,295	5	Arbuckle	3,692	9
286	Heyen, 24-22S-12W	1943	120	29,120	29,120	3	Arbuckle	3,652	2
287	James, 18-21S-12W	1943	80	16,485	16,485	2	Arbuckle	3,554	9
288	Jordan, 15-25S-14W	1936	260	59,250	487,710	7	Lans.-K.C.	3,722	5
289	Kipp, 27-25S-14W	1937	300	80,175	406,600	11	Lans.-K.C.	3,827	79
290	Leesburgh, 12-25S-13W	1938	600	303,199	1,317,149	16	Arbuckle	4,153	10
291	Max, 35-21S-12W	1938	500	135,728	534,788	12	Lans.-K.C. Arbuckle	3,356 3,570	16 5
292	McCandless, 30-24S-13W	1944	160	28,030	28,030	4	Simpson	4,251	16
293	Ranson, 7-24S-11W	1944	200	46,815	46,815	5	Viola	3,783	2
			(Combined with Zenith)						
294	Rattlesnake, 13-24S-14W	1938	40	10,105	61,655	1	Lans.-K.C.	3,608	48
295	Rattlesnake, W., 11-24S-14W	1944	40	4,185	4,185	1	Lans.-K.C.	3,759	7
296	Richardson, 36-22S-12W	1930	1,200	689,110	6,470,310	60	Arbuckle	3,537	62
297	Richland, 27-24S-14W	1944	160	14,500	14,500	4	Arbuckle	4,225	15
298	Riley, 28-23S-11W	1940	120	25,250	63,500	2	Lans.-K.C.	3,323	5
299	Rothgarn, 10-21S-13W	1943	120	26,355	39,025	3	Arbuckle	3,569	19
300	Shaeffer, 3-21S-13W	1941	300	33,831	210,545	5 1	Lans.-K.C. Arbuckle	3,404 3,546	4 4
301	Sittner, 33-21S-12W	1937	800	104,320	565,470	20	Lans.-K.C. Arbuckle	3,278 3,600	36 6
302	Sittner, S., 3-22S-12W	1938	700	197,961	976,511	20	Arbuckle	3,501	6
303	Snider, 3-21S-11W	1936	320	19,480	269,280	1 1	Simpson Arbuckle	3,365 3,324	6 20
304	Snider, S., 16-21S-11W	1938	360	83,948	405,673	8	Simpson	3,402	6
305	Spangenberg, 21-22S-12W	1943	40	12,140	21,040	1	Arbuckle	3,691	6
306	St. John, 23-24S-13W	1935	1,200	199,520	1,745,620	15 10	Lans.-K.C. Arbuckle	3,588 4,075	32 12
307	St. John townsite, 33-23S-13W	1944	280	36,000	36,000	7	Arbuckle	3,919	5
308	Stafford, 15-24S-12W	1940	600	357,123	1,463,423	20 1	Viola Arbuckle	3,836 3,945	14 10
309	Syms, 20-21S-12W	1943	40	11,522	11,522	1	Arbuckle	3,580	14
310	Van Lieu, 20-24S-13W	1943	120	51,500	92,550	3	Arbuckle	4,069	11
311	Zenith, 23-24S-11W	1937	5,600	3,649,840	17,786,990	373	Misener Viola	3,804 3,860	20 5
312	Zenith, W., 8-24S-11W	1943	400	94,240	101,000	10	Viola	3,798	5
	GAS POOL OF STEVENS COUNTY								
				MILLIONS CU. FT.					
313	Hugoton, 3-35S-34W	1944	2,000,000	83,008	445,008	389	Winfield Ft. Riley Florence	2,755 2,800 2,850	10 8 10
	OIL AND GAS POOLS OF SUMNER COUNTY								
				BARRELS					
314	Anness, 2-30S-4E	1937	40	11,410	78,510	1	Simpson	4,394	7
315	Caldwell, 17-35S-3W	1929	200	40,800	1,175,300	4	Simpson	4,765	19
316	Chandler, 4-35S-2E	1942	40	1,767	5,050	1	Mis. lime	3,413	26
317	Churchill, 25-31S-2E	1926	1,000	81,190	18,813,690	58	Stalnaker	1,820	25
318	Latta, 9-30S-2W	1927	400	45,800	885,680	12	Lans.-K.C.	3,042	14
319	Oxford, 25-32S-2E	1927	800	175,895	15,042,395	43	Stalnaker Layton Arbuckle	2,020 2,510 2,890	16 20 5
320	Oxford, W., 17-32S-2E	1926	160	10,845	535,570	3	Arbuckle	3,674	31
321	Padgett, 23-34S-2E	1924	1,800	57,855	2,133,855	20	Miss. lime	3,474	28
322	Rainbow Bend, W., 24-33S-2E	1926	160			3	Burbank Arbuckle		
323	Rutter, 21-33S-2E	1936	80	6,420	81,120	2	Mis. lime	3,315	27
324	Vernon, N., 15-35S-2E	1915	500		435,348	12	Mis. lime	3,443	22
325	Wellington, 33-31S-1W	1929	1,200	189,990	5,454,340	94	"Chat"	3,655	11
326	Zyba, 7-30S-1E	1937	160	25,400	58,000	4	Simpson	3,866	3
327	Zyba, SW., 22-30S-1W	1944	40	5,030	5,030	1	Simpson	3,917	12
				THOUSANDS CU. FT.					
328	Wellington, 33-31S-1W	1929	1,200	244,193		45	"Chat"	3,655	12
	OIL POOLS OF TREGO COUNTY								
				BARRELS					
329	Ellis, NW., 26-12S-21W	1944	120	18,380	18,380	3	Arbuckle	3,925	1
330	Wakeeney, 14-11S-23W	1934	640	48,530	561,750	6	Lans.-K.C.	3,619	8

drilling has been done to evaluate the size or importance of this find; however, the prospective gas areas have been considerably extended.

In *McPherson County*, new reserves were found by drilling in T. 17 S., R. 1 W., and T. 19 S., R. 1 W. The most gratifying results were obtained when new production was found by deepening in the Lindsborg field. The new reservoir is in the lower Viola. The older production was believed to be from the Viola and Simpson formations; however, many geologists are of the opinion that the oil thought to be from the Viola is really obtained from the Maquoketa dolomite. It is likely that many wells in Lindsborg will be deepened to this new source of petroleum during 1945.

Pratt County was the locale of much exploratory drilling during 1944, the results of which were three Simpson fields. As yet, they have been somewhat disappointing because no large wells have been found, like those at Carmi and Chitwood. The Chitwood area received the bulk of development work, with very gratifying results. Three formations, the Viola, Simpson and Arbuckle, have been found productive to date, the recoveries per well being estimated as approximately 300,000 bbl. of oil.

Russell County and the adjoining counties to the west, south and southeast, was a "sweet spot" in 1944 as it has been for many years. No new fields of much promise were found, but it continued to reward the operators who are active in the "oil country" of Kansas.

Sheridan County.—The discovery of oil in Sheridan County during 1943 was enthusiastically received and indicated a considerable portion of Northwest Kansas to have commercial oil possibilities. Following this lead, the Continental Oil Co. drilled the discovery well in the Adell field, T. 6 S. R. 27 W., during the first half of 1944. By the close of the year five wells had been completed for an average initial potential of 827 bbl. of oil from the Lansing-Kansas City, and three wells were in the process of completion or drilling. Much drilling will undoubtedly be done in this and surrounding areas during 1945.

Stafford County was the site of feverish leasing and drilling activities. The reward was the discovery of seven new fields, one of which, Ranson, was destined to join with the Zenith-Peace Creek field. Of the seven fields, the St. John Townsite and the McCandless, producing from the Arbuckle and Simpson formations, respectively, appear most likely to contribute substantially to the oil reserves of the state.

The *Hugoton gas field* of Southwestern Kansas experienced a tremendous upsurge in development work. The Carter Oil Co. completed a test in T. 22 S., R. 35 W., Kearny County, approximately 12 miles north of the Hugoton gas field, for 13,510,000 cu. ft. of gas. This gas is derived from the same zones that are productive in the Hugoton area. Most operators consider this as an important extension to the Hugoton field.

Exploratory Work

The amount of exploratory work done in Kansas during 1944 was approximately the same as in 1943, which had been more than in any previous year. During 1944 a change in emphasis from seismograph to core-drill methods was indicated. One major company did 32½ crew months of seismograph work in 1943, and in 1944 completed only 4½ crew months. Thirteen companies were engaged in seismograph work in the state and they averaged approximately 10 crew months per company. The estimated cost of this work is over one million dollars. The principal companies engaged in this type of work were the Phillips, Texas, Deep Rock, Carter and Skelly oil companies. Of the

new fields discovered in Kansas, 10 may be classified as found wholly or in part by seismograph, but only three of them owe their discovery entirely to this method.

Exploration by means of core drilling was conducted by 14 companies, as against 6 companies engaged in this method during 1943. Although this represents an increase of over 100 per cent in the number of companies doing core-drill work, the average number of core-drill months per company dropped from 18 in 1943 to 10 in 1944. Oil companies spent a total of 140 core-drill months in Kansas during 1944 for an increase of 32 core-drill months over the previous year. The greatest amount of work by this method was done by the Stanolind, Continental, Skelly and Amerada companies. Eighteen new oil and gas fields are indicated as having been located to some degree by core drilling.

Gravity surveys were carried on by three companies for a total of 68 weeks. The greatest amount of gravity meter work was done by the Continental Oil Company.

There were no magnetometer parties working in Kansas during the year.

Acknowledgments

The preparation of this report would have been difficult without the generous help of many individuals. Among those who contributed and were most helpful are W. A. VerWiebe, Paul Harper, Jim Smith, Virgil Cole, G. E. Abernathy, Howard Bryant and D. L. Chapman. The reports of the Conservation Division of the Kansas Corporation Commission were very helpful.

Oil and Gas Development in Kentucky in 1944

By Louise B. Freeman,* Coleman D. Hunter† and C. W. Donnelly‡

It is with pride that the authors of this paper report that during 1944 the production of petroleum in Kentucky passed its all-time peak, 9,496,985 bbl. being contributed. The delivery of natural gas, especially from eastern Kentucky, was maintained and possibly exceeded the highest deliveries of the past. To raise the production of oil and gas was not easy with inferior and worn-out equipment and the shortage of skilled labor. Reminiscent of the early days of the industry in the state, particularly in the hills of Elliott County, where mud roads often have gradients of 45°, was the replacement of worn-out trucks and tractors by oxen.

Of the total 9,496,985 bbl., 17 per cent was contributed by the part of Kentucky that is east of the Cincinnati arch, as compared with the total of 7,010,776 bbl. contributed in 1943, of which 25 per cent was contributed by eastern Kentucky. This discrepancy is due to the discovery of more new fields in western Kentucky rather than to a decrease in production in the eastern fields, where the average has been maintained by reconditioning and secondary recovery of old fields and further development of new pools reported for the first time in 1943.

In all, 1103 wells were known to have been drilled in the state during 1944, of which 659 were drilled in western Kentucky and 444 in eastern Kentucky. The exact number of wells drilled for any year is never known, as drilling permits are not required except when it is planned to drill through a workable coal seam. Of the total number of wells drilled, 459 were oil wells, 229 gas wells and 415 dry holes. The monthly production was as follows:

January	659,496
February	658,606
March	711,619
April	649,926
May	754,892
June	730,369
July	761,762
August	878,053
September	863,150
October	968,732
November	961,999
December	898,636

Western Kentucky

In western Kentucky 352 wells were completed as oil wells with a total initial production of 47,922 bbl. of oil, the average being 136 bbl. per well. Two wells produced gas, the total initial production being 1,594,000 cu. ft. One hundred and eighteen wildcat wells were drilled, of which 107 were dry holes and 11 were oil wells. Three of the latter proved to be the discovery wells of commercial pools.

Twelve new pools were discovered during 1944, none of major importance, as indicated in Table 2. The Utley pool, due to a stratigraphic trap on the flank of a closed structure, found oil in the McClosky at 2565 ft. in the discovery well, with initial production of 1000 bbl. The average daily production is now 227 bbl. from seven wells.

The East Poole field, with the discovery well in the Tar Springs sandstone at 1811

Manuscript received at the office of the Institute April 5, 1945.

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TABLE 1.—*Oil and Gas Production in Kentucky*

Line Number	County[a]	Year of Discovery	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil, Artificial Lift	Wells Producing[g] Dec. 1944: Gas
1	Allen	1866		68,983				2	2		
2	Ballard			None							
3	Barren	1919		8,190							
4	Bath			630				6	6		
5	Breckinridge	1921		1,055				2	2		
6	Butler	1937		54,315				61	21	40	
7	Caldwell			None				1	1		
8	Casey			None				2	2		
9	Christian			None				1	1		
10	Clay	1900	None	None	x	x	103	5	0		
11	Clinton	1921		44,021			169	65	12	53	
12	Crittenden			None				3	3		
13	Cumberland	1919		7,826				30	28	2	
14	Daviess	1919		536,021				66	41	25	
15	Edmonson			None				3	3		
16	Elliott	1917		14,003			x	16	4	12	
17	Estill	1918		315,071							
18	Floyd			12,434			1,587	47	4		43
19	Grayson			None				1	1		
20	Hancock	1930		124,455				4	2		2
21	Hardin			None				1	1		
22	Hart	1920		33,585							
23	Henderson	1931		2,385,376				110	62	47	
24	Hopkins	1920		None				10	10		
25	Jackson	1919		None			56	20		11	6
26	Johnson	1919		249,772			x	18	3		15
27	Knott	1906		None			498	35	5		30
28	Knox	1929		None			x	2			2
29	Larue			None				1	1		
30	Lawrence	1913		161,025							
31	Lee	1918		418,528							
32	Lewis			None							
33	Lincoln	1918		651				15	10	5	
34	Logan			152				1	1		
35	McCreary	1909		857				1	1		
36	McLean	1919		193,518				20	18	2	
37	Magoffin	1920		231,646			1,095	8	1		7
38	Marshall			None							
39	Martin	1898		52,646			522	46	3		43
40	Menifee	1902		12,774			x	15	9	11	
41	Metcalfe	1932		903							
42	Morgan			None							
43	Muhlenberg	1929		9,726				7	7		
44	Ohio	1919		516,998				25	21	4	
45	Owsley	1920		1,093							
46	Pike	1931		768			636	96	16	2	78
47	Powell	1918		99,951							
48	Rowan			None				1	1		
49	Russell			None				7	7		
50	Simpson	1921		580				1	1		
51	Taylor			None							
52	Todd			None				4	4		
53	Union	1942		3,296,120				237	47	191	
54	Warren	1918		53,452				3	3		
55	Wayne	1898		32,419				8	7	1	
56	Webster	1938		542,696				95	44	51	
57	Wolfe	1912		14,745				1	1		
58				9,496,985				1,103	415	459	229

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 1.—(*Continued*)

Line Number	Producing Formation: Name and Age[6]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	"Corniferous," Sil	D	Por	300	20	MC	Brassfield Silurian	540
2							Lower Ordovician	3,069
3	Louisville and Laurel, Sil	D	Por	500		MC	Brassfield	600
4								
5						MC	Silurian	1,534
6	Tar Springs, Hardinsburg, Jackson, MisU	S	Por	400–500		AM	Cypress	550
7								
8						MU	Knox	1,200
9	Aux Vases, MisU	S	Por	1,035	8	MU	Trenton	
10	"Corniferous," Sil	D, SD	15	1,000 – 1,600	30	MU	Silurian	1,700
11	Trenton & Knox, Ord M and L	L, D	Cav	400 – 1,837	30	H, MU	Knox	1,845
12								1,250
13	Trenton, OrdM	L	Cav	400		H	Lower Ordovician	835
14	Jackson, Bethel, Cunningham, McClosky, MisU	S, OL	Por			A, F	Mississippian	
15	Mid. Devonian, Dev	L	Por	1,300		MU	Silurian (top)	1,370
16	Weir, MisL	S	Por	900		AF	Knox, L. Ord	4,191
17	"Corniferous," Sil	D, S, D	15	800	30	MU	Knox, L. Ord	2,640
18	Pen, Maxon, "Big Lime," "Big Injun," Pen, MisU	S, L	Por	900–3,100		MC	Silurian	3,643
19						MU	Silurian	1,524
20	Tar Springs, MisU	S	Por	450–500			McClosky and Silurian	1,900
21							Silurian	986
22	"Corniferous," "Blue Sand," Sil	D	Por	500–1,000		MC	Lower Ordovician	1,920
23	Pen, Waltersburg, Tar Springs, Hardinsburg, McClosky, Pen, MisU	S, OL	Por	1,800–1,900		AF	Devonian	4,700
24	McClosky, MisL	OL	20	2,400			Devonian	4,927
25	"Corniferous," Sil	D, SD	20	1,100		MU	Silurian	1,200
26	"Big Six" Sil	S	Por	2,380	40	MC	Silurian	2,430
27	Pen Maxon, "Big Lime," "Big Injun," Black Shale, Pen, MisL and U	S, L, D, LS, H	Por	1,250–3,000		MC	Upper Ordovician	3,706
28	"Corniferous," Sil	D, DS	15–20	650–1,150	30	MU	Lower Ordovician	5,000
29	Silurian	D	Por	920		MU	Trenton	1,380
30	Weir, MisL	S	Por	900			Silurian	4,975
31	Corniferous, Sil	D, DS	15	825–1,250	70–100	MU	Lower Ordovician	3,527
32	Corniferous, Sil	D, DS			700	MU	Silurian	700
33	OrdU	D		130	20	MU	Ordovician Knox	1,680
34	Dev and Sil	L, D		1,200		MU	Silurian	1,450
35	Beaver, Sunnybrook, MisL, OrdM	L	Por, Cav	750–1,200			Lower Ordovician	2,515
36	Tar Springs, MisU	S	Por	1,600			McClosky	2,000
37	Pen, Maxon, Big Lime, Black Shale, Pen, MisL	S, L, H	Por	800–4,000	10–800		Ordovician	5,343
38							Lower Ordovician	3,182
39	{ Pen, Maxon, Pen; Big Lime, MisU; Black Shale, MisL	S, L, H	Por	700–3,000	10–600		Silurian	3,325
40	Corniferous, Sil	D, DS	Por	500–1,230		MU	Ordovician	
41						MU	Knox-L. Ord.	1,785
42	Salt Sand, Pen	S	Por				Silurian	2,030
43	Hardinsburg, MisU	S	Por			A	Silurian	5,065
44	Tar Springs, McClosky, MisU	S, OL	Por			A	Silurian	2,505
45	Big Lime, MisU	L	Por	1,100	15	MU	Silurian	1,962
46	{ Pen, Maxon, Pen; Big Lime, MisU; Black Shale, MisL	S, L, H	Por	80–4,000	10–800		Ordovician	5,343
47	Corniferous, Sil	D, D, S	Por	15	30	MU	Silurian	900
48	Corniferous, Sil	D, DS	Por			MU	Brassfield, L. Sil	1,040
49	Sunnybrook, OrdU	L	Cav			H	Trenton	630
50	Corniferous, Sil	D	Por			MU	Brassfield	745
51	Corniferous, Blue Sand, Sil	D	Por	600		MU	Silurian	650
52						MU	Silurian	1,862
53	Pen, Waltersburg, Tar Springs Cunningham, McClosky, Pen, Mis	S, OL	Por	800–2,860		A	Upper Mississippian	2,955
54	{ Brownsport, SilU; Jeffersonville, DevM	L, D	Por	500–1,000	20	rMU	Knox, L. Ord	2,870
55	Beaver, MisL	L	Cav	400–500		MC	Lower Ordovician	1,810
56	{ Pen, Cypress, Pen; McClosky, MisU	S, OL	Por	2,200–2,400		AF	Devonian	3,217
57	Corniferous, Sil	D, DS	Por	1,270–1,380		MU	Lower Ordovician	3,785
58								

ft. and initial production of 205 bbl., has a daily average production of 1977 bbl. from 23 wells. The Powells Lake pool, with the discovery well in the Waltersburg sandstone at 2281 ft. and initial production of 68 bbl., has since been found to have some accumulation in a Pennsylvanian sandstone.

The major development in western Kentucky during 1944 was that of the Uniontown pool, Union County. In this pool, discovered in November 1942, the average daily production at the end of 1944 was about 12,000 bbl. from 164 wells, and the cumulative production since the discovery has been 2,408,199 bbl. The oil is obtained from any combination of six pay zones: Pennsylvanian sand at about 1000 ft., Waltersburg at 1750 ft., Tar Springs at 1840 ft., Hardinsburg at 1900 ft., Cypress at 2300 ft. and McClosky at 2650 feet.

In the Smith Mills pool, Henderson County, discovered in August of 1942, the average daily production is about 3650 bbl. from 95 wells, and the cumulative production since the discovery has been 5,148,809 barrels.

TABLE 2.—*Summary of Drilling Operations in Western Kentucky in* 1944

County	Pool	Location	Discovery Date	Number of Wells		Daily Average, Bbl.		Total for 1944, Bbl.	Accumulated Production, Bbl.
				1943	1944	1943	1944		
Daviess	Birk City	P-27	4-13-38	104	108	311	247	146,747	2,476,760
	Curdsville	3, 4-O-27	9-26-44		1	0	19	1,970	1,970
	Panther	11-N-27	6-2-43	4	11	206	226	80,225	109,924
	St. Raphael	20-O-27	5-31-44	0	1	0	4	988	988
	Thruston	9, 11-P820	5-6-39	2		3		1,909	23,860
Henderson	Burbank Chapel	6-P-21	12-20-44	0	1	0	72	2,232	2,232
	Cairo	17-O-23	6-30-43	1	0	25		2,460	5,535
	Corydon	18, 19-P-22	3-1-39	5	22	47	48	18,240	193,517
	Geneva	16-Q-22	12-20-43	4	17	298	216	108,630	120,322
	Gilmore	25-P-27	8-27-38	9	9	100	78	34,922	184,346
	Greenbriar	24-O-24	7-14-43	1	1	28	10	8,869	11,493
	Hebbardsville	18, 23-P-26	8-24-40	13	14	82	57	22,914	180,043
	McKinley	24-O-25 4-N-25	7-19-44	0	5		48	10,783	10,783
	Poole	2, 3, 8, 9-N-23 14-N-24	6-2-43	14	23	334	731	203,497	285,950
	Reed	11, 19, 20-Q-26	5-17-39	5	5	64	24	14,462	59,581
	Robards	21, 22-O-23	2-17-43	9	10	200	148	69,952	149,909
	Rock Springs	4-O-23	9-12-44	0	1	0	19	3,773	3,773
	Smith Mills	3-P-21 23, 24-Q-21	8-19-42	81	95	8,936	3,647	1,753,609	5,148,809
	South Reed	5-P-26	11-3-40	1	11			0	864
	Spottsville	22-Q-25	8-9-39	4	4	45	30	15,580	157,175
	Zion	25-P-25	2-17-43	1	1	5	9	4,615	7,323
McLean	Livermore	6-L-29	3-22-39	5	5	91	74	31,362	176,503
	North Livermore	24-M-29	5-1-43	1	1	31	22	7,648	13,445
Muhlenberg	Belton	21-I-30	2-1-39	3	3	14	12	6,160	56,430
Ohio	Barnett Creek	13-M-31	10-27-43	1	1	8		356	597
Union	Chapman	3-O-20	12-29-43	1	1	17	12	6,653	7,177
	Hitesville	4-O-21 24-P-21	7-7-43	9	30	264	776	314,034	362,532
	Morganfield	12, 13-O-19	5-19-43	6	11	247	199	94,767	150,706
	Powells Lake	16-Q-20	8-16-44	0	5	0	269	31,479	31,479
	Raleigh	13-O-18	10-27-43	2	5	55	41	34,249	39,622
	St. Vincent	9, 12-O-20	6-30-43	17	28	1,669	829	492,998	849,748
	Spring Grove	20-O-18	11-19-41	10	10	111	108	56,060	142,791
	Sturgis	17-M-19	12-20-44	0	1	0	27	831	831
	Uniontown	16-P-20 20-P-19	11-11-42	22	164	541	11,081	2,193,711	2,408,199
	Utley	16-P-21	2-24-43	2	7	59	195	109,745	128,586
	Wabash Island	12-P-18	10-8-42	1	1	4		1,353	3,541
	Wathen	1, 6, 10-O-19	6-10-42	8	8	162	37	20,188	142,148
Webster	Clay	23-M-21	9-29-43	2	7	18	22	7,061	8,732
	East Clay	9-L-21	8-23-44	0	2	2	0	1,635	1,635
	East Poole	10-N-23	7-14-43	1	34	13	2,188	355,938	358,642
	Pratt	14-N-24	7-21-43	4	12	157	207	155,102	179,158
	Sebree	22-N-24	12-21-38	7	8	50	31	12,786	71,223
	Wanamaker	17-N-23	10-25-44	0	1	0	31	6,147	6,147

Ten test wells through the Devonian were drilled during 1944 in the west Kentucky basin in Butler, Breckinridge, Christian, Grayson, Logan, Ohio and Todd Counties. All of these were dry holes.

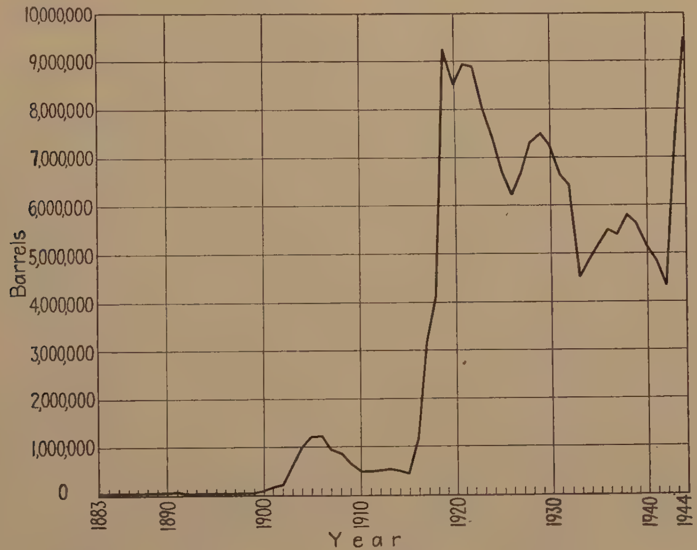

FIG. 1.—ANNUAL PRODUCTION OF PETROLEUM IN KENTUCKY, 1883 TO 1944.

EASTERN KENTUCKY

The Big Sandy gas field, which is in Floyd, Knott, Pike, Martin, southern Johnson and southeast Magoffin Counties, still holds the spotlight for development in eastern Kentucky. In this area, which encloses 2000 square miles of proven gas production, 217 gas wells, 33 dry holes and 12 oil wells were completed during 1944, making a total of 3105 gas wells, 397 dry holes and 112 oil wells drilled. Gas from the Devonian-Mississippian black shale is still responsible for 57.3 per cent of gas wells drilled.

The only other gas of importance developed in eastern Kentucky during 1944 was from nine wells drilled in the McKee gas field, Jackson County, six in the Oneida field, Clay County, and one in the Artemus gas field, Knox County.

One of the largest potential gas areas in eastern Kentucky as yet untested lies in Leslie and Clay Counties. During 1944 large blocks of acreage were acquired by a major oil corporation and a well probably will be drilled in the area near Hyden, the county seat of Leslie County. The company probably is seeking oil from the Silurian or deeper horizons, but this test will be of great importance to gas operators.

No new oil pools were discovered in eastern Kentucky during 1944, and the 400 bbl. per day increase in production was due largely to the reconditioning and development of old producing areas by the Ashland Oil and Refining Company.

On and around the Burke dome in Elliott County, 12 new oil-producing wells and 4 dry holes were drilled during 1944, bringing the total production up to around 100 bbl. per day. This new field is delivering only 50 bbl. per day, as all equipment has not yet been installed. In Menifee County the Ashland Oil and Refining Co. has increased its heavy Ragland type oil production to 200 bbl. per day

with several wells drilled in a small area on Indian Creek. The accumulation is in the Lockport (Corniferous of the driller). Five dry holes were drilled outside of this area. There are no pipe lines to the fields in either Menifee or Elliott County, and the oil is taken out by truck.

In the Mummie pool, Jackson County, 15 oil wells and one dry hole were drilled in 1944. These have been connected by pipe line and are delivering something over 100 bbl. per day.

The other new oil production comes from 10 wells drilled in the Big Sandy gas fields, 3 being in the old Wolfe Creek Maxon oil pool. Cuttings saved from five wells, drilled through the Silurian section in Pike and Floyd Counties, made it possible to definitely correlate the so-called "Corniferous" with that higher on the Cincinnati arch and with the standard section. This study indicated that in the area of thick "Corniferous" it includes Onondaga, Oriskany, Helderberg, Cayugan and Lockport, whereas only the Lockport is present on the east flank of the Cincinnati arch where so much petroleum has been produced in the past.

Central Kentucky

There was increased activity in Clinton and Cumberland Counties following the discovery of shallow oil of very high gravity in a lower Mississippian limestone, about 70 ft. above the Chattanooga shale. Other wells were drilled in the area, encountering production at 190 to 240 ft. The initial production was 20 to 200 bbl. per day and the average about 60 bbl. per day. The oil is of paraffin base, and very light green. However, these wells did not hold up and the first was abandoned about 3 months after it was drilled. The production from the Desda field, Clinton County, is derived from an Ordovician limestone called "Granville" by the drillers and possibly is accumulation in a reeflike structure in the Cynthiana (Upper Trenton). The average initial production from this area is 40 bbl. per day. The oil is about 40°A.P.I. and is dark green. The wells are long-lived, some having been produced for 40 years.

Several wells were drilled to the Knox dolomite in Clinton and Cumberland Counties. A Knox test was drilled in Casey County and another is being drilled in Lincoln County. There has been much leasing, a little drilling of shallow wells, and much discussion of deep wells on the south flank of the Jessamine dome of the Cincinnati arch, in Lincoln, Casey, Boyle and Marion Counties. Small wells have been developed in the Brassfield limestone, which there is directly overlain by the Chattanooga shale and there have been showings in the Trenton that may later produce. It is in that area that faulting, some of which is possibly late Devonian, has been responsible for the preservation of Devonian limestone, which elsewhere on the arch is absent.

Five wells were drilled in Rockcastle County during 1944. The original plan was to test the Lockport, but as it is absent there most of the wells were deepened to the upper Ordovician.

During the year considerable interest was exhibited in the possibilities for deeper production, and some leasing has been done with the view to testing the Cambrian sandstones on the Cincinnati arch. No well has yet penetrated to such stratigraphic depths in Kentucky.

Acknowledgment

The writers wish to acknowledge the valuable assistance given by many oil-company geologists who contributed data on individual counties. Many of the drilling data for southern Kentucky were contributed by Mr. Woodson Diamond. They wish also to acknowledge the cooperation of Mr. D. J. Jones, State Geologist, Mr. D. D. Beecher, Operating Manager, Kentucky West Virginia Gas Co., and Mr. W. H. Keffer, Vice President, Ashland Oil and Refining Company.

Petroleum Production in Louisiana for 1944

By J. Huner, Jr.,* C. J. Bonnecarrere,† and P. A. Bloomer, Jr.†

Since 1941 not more than 15 per cent of all wildcat wells drilled in Louisiana have been successful. This figure is not too discouraging, especially in view of the fact that during the same period approximately 80 per cent of all wells (average 701 wells per year) drilled in or adjoining producing areas were successfully completed. However, a somewhat discouraging aspect concerning Louisiana's wildcat completions is that in 1942 only 12 out of 20 fields found were oil fields; in 1943, only 13 out of 24; and in 1944, only 8 out of 21. This means that an operator has less than a 50:50 chance of finding an oil field. In other words, it is more likely that he will find a gas-condensate field.

This fact has become increasingly evident as the data for each year are compiled and compared. Yet, strangely enough, operators are reluctant to accept this fact and plan accordingly. Certainly they cannot continue to search for oil fields and, for the most part, end with shut-in gas-condensate wells. The reason for shutting in is that there is no immediate and satisfactory market for all the gas being discovered.

The solution, and it is a very satisfactory one, as experience in Louisiana has already demonstrated, is cycling. The advantages of this type of operation of gas-condensate fields, especially where the entire field is pooled and unitized, should be self-evident. These advantages will become increasingly more important, especially now that legislatures, regulatory bodies, royalty owners, and others are beginning to realize that "reasonable development" in a field is not indicated by the number of wells completed, but rather by the method of development. To complete a great many wells that can produce at only partial capacity is waste. Producing hydrocarbons from these wells and not subjecting them to processing by surface operations, in order to recover all liquefiable hydrocarbons, is waste. Permitting bottom-hole pressures to drop or gas-oil ratios to increase because of excessive production is waste. Loss of leases and of wells because of inability to produce or to meet lease obligations is waste. Therefore, it is becoming increasingly apparent that a reservoir entirely pooled and unitized with a minimum number of completions, but over which there is exerted careful control so as to provide maximum recovery and the processing of all hydrocarbons brought to the surface, is the only logical and reasonable method of developing a gas-condensate field.

Oil Production

Twenty-one new fields, including three rediscoveries, were found during 1944. Three of these new discoveries—Delhi in northeast Louisiana, Good Hope in southeast Louisiana, and West Tepetate in southwest Louisiana—should add considerably to Louisiana's oil reserves. The other discoveries were either gas condensate or of apparently little consequence.

State-wide production for 1944 was 136.6 million barrels of crude oil and condensate; amounting to about 8.1 per cent of the

Manuscript received at the office of the Institute June 15, 1945.

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TABLE 1.—*Oil and Gas Production in Louisiana*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
	NORTH LOUISIANA										
1	Ada, *Webster*	1944		0	0	640	0	0	1	1	0
2	Ajax, *De Soto and Natchitoches*	1941	Abandoned	6,405	0		0	0	2	0	0
3	Athens, *Claiborne*	1940	40	25,452	12,191[2]	640	2,213	1,131	3	1	0
4	Bear Creek, *Bienville*	1937	0	125,001	15,062[2]	6,400	11,716	1,769	7	1	0
5	Beekman, *Morehouse*	1942	0	1,119	0	320	62	0	1	0	0
6	Bellevue, *Bossier*	1921	1,360	10,999,638	204,398	160	2,646	11	459	11	4
7	Benson, *De Soto*	1928	Abandoned	6,494	0		107	0	5	0	0
8	Benton, *Bossier*	1944		2,216	2,216	640	35	35	1	1	0
9	Bethany,[1] *Caddo*	1916	20	3,068[4]	180	2,560	0[4]	0	14	0	0
10	Big Island, *Rapides*	1942	Abandoned	3,828	0		0	0	1	0	0
11	Blue Lake, *Sabine*	1928	340	24,942[13]	0[16]	0	0[13]	0	11	0	0
12	Caddo (includes Hosston, Pine Island and Vivian areas), *Caddo*[1].	1905	65,000	159,922,533[25]	2,096,293		145,768[25]	873	4,880	18	41
13	Calvin, *Winn*	1942		4,852[2]	984[3]	640	26	26	1	0	0
14	Carterville-Sarepta, *Bossier and Webster*	1922	4,250	2,895,259	38,831	0	42,712	8	201	0	0
15	Caspiana, *Caddo*	1925		0	0	400	193[10]	x	5	0	0
16	Catahoula Lake, *La Salle*	1942	280	319,288	156,939	0	132	55	5	1	0
17	Cedar Grove, *Caddo*	1915		0	0	3,840	0[5]	0	0	0	0
18	Clarks, *Caldwell*	1941		0	0	160	0	0	1	0	0
19	Converse, *Sabine*	1932	5,760	2,591,058	83,162	0	60	4	200	1	6
20	Cotton Valley, *Webster*	1922 1926 1936 1936 1944	2,000	46,495,428	3,181,867	12,640	381,606	63,701	458	3	2
21	Cypress Bayou, *La Salle*	1941	80	144,297	32,141		40	5	2	0	0
22	Delhi, *Richland*	1944	40	2,508	2,508		1	1	1	0	0
23	Dixie, *Caddo*	1929	1,500	40,835[6]	0[36]				56	0	0
24	Driscoll, *Bienville*	1936		27,544	2,078[3]	1,500	17,195	1,513	4	0	2
25	East Nebo, *La Salle*	1943	80	54,206	47,759	0	38	31	2	1	0
26	Elm Grove, *Bossier*	1916	400	3,738,272	105,031	14,600	194,714	83	251.	2	0

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Extends into Texas.
[2] Condensate only.
[3] Produced only in June and July, 1944.
[4] Included under Waskom prior to 1941.
[5] Included under Caddo prior to 1941.
[10] Included under Elm Grove prior to 1940.
[13] Included under Zwolle prior to 1941.
[16] See Zwolle.
[25] Included Dixie and Cedar Grove prior to 1941.
[36] SeeCaddo.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
						NORTH LOUISIANA							
1	0	0	0			Rodessa, CreL	S	Por	5,460	70	x	Hosston	7,600
2	0	0	0	42		Paluxy, CreL	S	Por	3,209	5	D	Paluxy	3,500
3	0	0	3	61		Hosston, CreL	S	Por	6,166	10	DF	Hosston	6,706
4	0	0	6	59		Pettit, CreL	S	16	6,605	25	D	Hosston	8,016
						Hosston, CreL	S	12.5	7,515	15	D		
5	0	0	0			Cotton Valley, Jur	S	Por	3,700	20		Eagle Mills salt	6,956
6	0	163	0	18–19		Nacatoch, CreL	S	Por	300	30	DF	Eagle Mills salt	9,070
						Rodessa, CreL	OL	Por	1,700	x	DU		
7	0	0	0			Paluxy, CreL	S	Por	3,000	10	A	Paluxy	3,440
8	0	0	0	62		Cotton Valley, Jur	S	Por	8,104	40	D	Cotton Valley	8,765
9						Nacatoch, CreL	S	Por	930	25	A	Mooringsport	3,758
						Washita, CreL	S	Por	2,400	10	A		
						Paluxy, CreL	S	Por	2,830	10	A		
10	0	0	0			Wilcox, Eoc	S	Por	5,150	2	D	Midway	7,105
11	0	1	0	42–45		Chalk Series, CreU	C	Fis	2,100	x	T	Paluxy	4,503
				19–21		Nacatoch, CreU	S	Por	800	30	Af		
				28–39		Saratoga-Annona, CreU	C	Fis	1,400	250	Af		
				23–44		Tokio, CreU	S	Por	2,000	13	Af		
12	0	1,337	17	26–43		Paluxy, CreL	S	Por	2,300[6]	x	Af	Igneous below Eagle Mills salt	11,419
						Ferry Lake, CreL	A	Fis	2,700	x	Af		
						Rodessa, CreL	OL	Por	2,800[6]	x	Af		
				42–44		Sligo, CreL	OL	Por	3,620	x	Af		
						Hosston, CreL	S	Por	3,900	15	Af		
13	0	0	0	72		Paluxy, CreL	S	Por	5,784	10	x	L Cretaceous	9,719
14	0	22	0	26–43		Tokio, CreU	S	Por	2,675[6]	30	A	Cotton Valley	10,070
15	0	0	0			Nacatoch, CreU	S	Por	800	20	N	Cotton Valley	9,141
						Eagleford, CreU	S	Por	2,450	8	N		
16	2	3	0	39–43		Wilcox, Eoc	S	Por	3,817[6]	50	D	Midway	5,400
17	0	0	0			Tokio, CreU	S	Por	2,450	25	A	Hosston	6,001
18	0	0	0			Wilcox, Eoc	S	Por	2,173	12	Df	Wilcox	4,006
19				38–45		Saratoga-Annona, CreU	C	Fis	1,600	60	Af	Hosston	8,929
				41–42		Paluxy, CreL	S	Por	3,604	20	Af		
				27–30		Ozan, CreU	S, L	27	2,500	30	A		
				51–53		Rodessa, CreL	S	24	3,900[6]	35	A		
20	6	33	118	49–67		Hosston, CreL	S	17	5,500[6]	10	A	Smackover	10,686
				41–65		Cotton Valley, Jur	S	17	7,900[6]	40	A		
				70		Smackover, Jur	S	Por	10,651	30	A		
21	0	1	0	44		Wilcox, Eoc	S	Por	4,706	10	AM	Midway	5,976
22	1	0	0	41.7		Tuscaloosa, CreU	S	Por	3,273	20	NL	L Cretaceous	3,273
23	0	4	0	38		Paluxy, CreL	S	Por	2,400	10	T	Mooringsport	3,514
24	0	0	2			Rodessa, CreL	OL	16	5,960	15	D	Hosston	7,693
						Hosston, CreL	S	12	7,160	25	D		
25	2	0	0	38		Wilcox, Eoc	S	Por	3,896	14	D	Midway	5,208
26	0	39	12	29–30		Nacatoch, CreU	S	Por	800	30	A	Cotton Valley	8,647
						Ozan, CreU	S	Por	1,550	12	A		
						Tokio, CreU	S	Por	1,675	50	A		
						Paluxy, CreL	S	Por	2,400	10	A		

[6] Multiple sand production.

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[c]: To End of 1944	Gas Production: Millions Cu. Ft.[c]: During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944: Completed	Number of Oil and/or Gas Wells: During 1944: Abandoned
27	Elm Ridge, *La Salle*	1942	40	7,196	0		5	0	1	0	0
28	Epps, *East and West Carroll*	1928		0	0	1,280	11,201	1,225	5	0	0
29	Funny Louis Bayou, *La Salle*	1941		0	0	160	0	0	1	0	0
30	Grand Cane, *De Soto*	1941	80	1,400	0		0	0	2	0	0
31	Greenwood, *Caddo*	1940		0	0	320	1,429	727	3	0	0
32	Grogan, *De Soto*	1937	Abandoned	28,671	0		0	0	1	0	0
33	Haynesville,[8] *Claiborne, and Webster*	1921	12,000	84,169,133	3,780,243		945,604	7,170	922	4	11
34	Holly, *De Soto*	1930	400	1,342,355	271,981	160	229	31	38	21	0
35	Holly Ridge, *Tensas*	1943	960	891,970[35]	851,742[35]	640	1,092	1,062[35]	26	23[9]	0
36	Homer, *Claiborne*	1919	3,020	74,013,090	1,014,890		8,747	566	642	0	2
37	Indian Bayou, *La Salle*	1941	40	115,429	34,745		35	5	1	0	0
38	Lake Bistineau, *Bienville*	1916		38,749[2]	5,750[2]	5,500	56,767	11,758	29	0	0
39	Lake End, *Red River*	1942	40	2,003	696		0	0	1	0	0
40	Lake St. John, *Concordia and Tensas*	1942	3,000	1,053,605	651,137	1,000	2,052	1,740	37	17	0
41	Larto Lake, *Catahoula*	1941	40	97,605	30,243		0	0	1	0	0
42	Lisbon, *Claiborne and Lincoln*	1936	8,000	11,015,182	440,304	5,120	43,605	15,638	285	10	30
43	Logansport, *De Soto*	1938		167,818[2]	48,340[2]	14,000	47,979	17,185	19	2	0
44	Longwood, *Caddo*	1926		22,261[4,2]	2,991[4]		8,384[4]	168	38	0	0
45	Lucky, *Bienville*	1943		2,307[2]	1,313[2]	3,200	580	298	6	5	0
46	Manifest, *Catahoula*	1942	40	4,086	1,596		0	0	1	0	0
47	Monroe, *Ouachita, Morehouse and Union*	1916		0	0	251,000	3,716,653	236,186	1,534	39	0
48	Nebo-Hemphill, *La Salle*	1940	5,920	10,983,372	3,336,551		11,581	3,388	152	4	0
49	North Carterville, *Bossier*	1942	400	162,408	76,512		31	31	6	0	0
50	Northeast Lisbon, *Claiborne*	1941		0[11]	0[11]	8,000	0	0	10	7[9]	0
51	Oakland, *Union*	1928	60	8,892	422[12]		0	0	7	0	0
52	Olla, *La Salle*	1940	8,300	16,810,492	3,280,739	8,300	33,099	11,471	192	1	1
53	Pleasant Hill, *De Soto, Sabine*	1927	2,000	1,540,663	22,181		571	82	64	0	1
54	Red River-Bull Bayou, *De Soto and Red River*	1912	37,000	57,737,439	331,707	3,000	311,644	956	1,447	1	16
55	Richland, *Richland*	1926	Abandoned	0	0		460,619	0	313	0	0
56	Rodessa, *Caddo*[1,8]	1930	10,000	82,249,452	2,954,725	8,000	536,125	33,965	504	0	15
57	Ruston, *Lincoln*	1937		2,669[2,3]	2,669[2,3]	1,920	2,906	2,906		2	0

[8] Extends into Arkansas.
[9] Two dual completions.
[11] Combined with Lisbon production.
[12] Produced only January, February and March, 1944.
[35] Includes North Holly Ridge.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
27	0	0	0	41		Wilcox, Eoc	S	Por	4,572	13	AM	Midway	5,976
28	0	0	5			Monroe Gas Rock, CreU	C	Por	2,302	25	D	Eagleford	2,820
29	0	0	0			Sparta, Eoc	S	Por	1,465	10		Wilcox	4,000
30	0	0	0			Paluxy, CreL	S	Por	2,820	10		Paluxy	2,858
31	0	0	2			Paluxy, CreL	S	Por	2,549	20	AM	Hosston	6,431
32	0	0	0	38–39		Paluxy, CreL	S	Por	2,929	5	D	Paluxy	2,961
33	143	196	0	35–36		Tokio, CreU	S	Por	2,725	25	A	Smackover	11,254
				35		Rodessa, CreL	OL	Por	4,250	20	AL		
				38–42		Sligo, CreL	OL	18	5,200	20	AL		
				44		Cotton Valley, Jur	S	Por	8,830	65	A		
34	6	20	3	37–39		Eagleford, CreU	S	Por	2,538	11	NL	Paluxy	4,485
35	22	1	2	38		Wilcox, Eoc	S	Por	3,000	20	D	L Cretaceous	10,022
						Tuscaloosa, CreU	S	26	8,347	50	D		
36	0	316	0	35–38		Nacatoch, CreU	S	Por	1,000	50	DF	Eagle Mills salt	6,019
				35–38		Tokio, CreU	S	Por	1,900	50	DF		
				46		Cotton Valley, Jur	S	Por	4,242	74	DF		
37	1	0	0	42.8		Wilcox, Eoc	S	Por	4,294	10	AM	Midway	5,905
38	0	0	9			Ozan, CreU	S	Por	1,950	25	AF	Cotton Valley	8,532
						Tokio, CreU	S	Por	2,525	25	AF		
						Sligo, CreL	OL	17	5,000	40	AF		
						Cotton Valley, Jur	S	12	8,400	x	AF		
39	0	1	0			Nacatoch, CreU	S	Por	1,224	x	D	Hosston	7,120
40	22	7	0			Sparta, Eoc	S	Por	2,131	20	D	Rodessa	9,994
				32–44		Wilcox, Eoc	S	Por	3,396[6]	65	D		
				55		Tuscaloosa, CreU	S	Por	9,000	50	D		
41	0	1	0	46		Wilcox, Eoc	S	22	5,108	25		Midway	7,031
42	0	101	6	32–33		Sligo, CreL	OL	18	5,100	10	DL	Eagle Mills salt	12,592
				42		Hosston, CreL	S	Por	5,300	7	DL		
						Cotton Valley, Jur	S	13	8,400[6]	30	DF		
				56		Smackover, Jur	L	Por	10,150	100	DF		
43	0	0	15			Rodessa, CreL	OL	18	4,825	50	A	Hosston	6,271
						Sligo, CreL	OL	12	5,980	20	A		
44	0	0	2			Nacatoch, CreU	S	Por	870	40	A	Hosston	6,200
						Paluxy, CreL	S	Por	2,690	20	A		
						Sligo, CreL	OL	Por	5,590	40	A		
						Hosston, CreL	S	Por	6,000	50	A		
45	0	0	1			Sligo, CreL	OL	Por	6,664	30		Cotton Valley	10,329
						Hosston, CreL	S	Por	7,864	25			
46	0	1	0	20		Sparta, Eoc	S	Por	1,810	7		Wilcox	4,554
47	0	0	1,396			Monroe Gas Rock, CreU	C	Por	2,145	30	MC	Morehouse	10,475
						Second Sand, CreU	S	Por	2,265	10	MC		
48	68	76	1			Cockfield, Eoc	S	Por	1,420	15	AL	Midway	5,301
						Wilcox, Eoc	S	25	3,340	400	AL		
49	4	2	0	38–39		Sligo, CreL	OL	Por	6,048	42	AL	Hosston	6,382
50	0	0	10			Hosston, CreL	S	Por	5,100[6]	25	NL	Cotton Valley	7,912
						Cotton Valley, Jur	S	Por	7,785	30	NL		
51	0	0	0			CreU	S	Por	2,200	10		U Cretaceous	3,001
52	31	133	7	26–32		Wilcox, Eoc	S	20	2,040[6]	154	AL	Rodessa	8,997
53	0	23	0	40–43		Paluxy, CreL	S	Por	3,100	15	N	Mooringsport	5,063
54	0	68	16			Nacatoch, CreU	S	Por	725	30	AF	Hosston	6,479
						Saratoga-Annona, CreU	C	Por	850	x	AF		
						Paluxy, CreL	S	Por	2,450[6]	10	AF		
55	0	0	0			Tokio, CreU	S	Por	2,349	76	A	Cotton Valley	9,986
56	36	203	102	40–70		Rodessa, CreL	S, L / OL	15 / 25	5,400[6]	125	AF	Eagle Mills salt	11,486
57	0	0	2			Sligo, CreL	OL	Por	5,190	15	A	Hosston	5,822
						Hosston, CreL	S	Por	5,725	25	A		

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[c] To End of 1944	Gas Production: Millions Cu. Ft.[c] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
58	Shongaloo, *Webster*	1921	190	194,529	14,970	5,600	73,000	0	96	1	1
59	Shreveport, *Caddo, and Bossier*	1913	2,200	6,966,694	690,401	6,000	16,774	3,096	62	0	3
60	Sibley, *Webster*	1936		50,236[2]	13,465[2]	1,000	9,339	2,096	6	0	0
61	Simsboro, *Lincoln*	1935		19,785[2]	4,537[2]	920	14,087	2,464	2	0	0
62	Sligo, *Bossier*	1922	2,000	4,485,335	459,682	13,040	224,618	31,131	181	1	2
63	South Jena, *La Salle*	1941	600	318,455	57,806		0	0	7	0	0
64	Spider, *De Soto*	1914		0	0	1,280	341	0	6	1	0
65	Spring Ridge, *Sabine*	1931	160	*x*	0	40	0	0	2		0
66	Standard, *La Salle, Caldwell*	1940		0	0	1,500	2,317	814	4		0
67	Sugar Creek, *Claiborne*	1930	440	2,339,343	371,892	4,000	88,658	8,944	44	0	1
68	Summerville, *La Salle*	1940	740	417,856	100,510		617	7	13	0	0
69	Sutherlin, *De Soto*	1920		0	0	1,280	224	0	4	0	0
70	Tremont, *Lincoln*	1944	0	1,263[2]	1,263[2]	320	40	40	1	1	0
71	Trenton, *De Soto*	1944	40	840	840		0	0	1	1	0
72	Trout Creek, *La Salle*	1941	250	187,201	28,065		86	16	6	0	0
73	Tullos-Urania-Georgetown, *La Salle, Grant, and Winn*	1925	6,600	27,295,422	677,377		5	0	533	0	0
74	Waskom, *Caddo*	1924		33,914[2,14]	2,970[2]	1,600	14,324	354	32	0	0
75	White Sulphur Springs, *La Salle*	1927	350	12,290	0		0	0	12	0	0
76	Willow Lake, *Catahoula*	1941	80	297,876	97,934		40	20	2	0	0
77	Zenoria-Little Creek, *La Salle*	1938	3,000	3,589,055	834,480		4,878	826	76	0	0
78	Zwolle, *Sabine*	1928	2,800	15,008,496	141,261[15]		0	0	382		9
	SOUTH LOUISIANA										
79	Abbeville, *Vermilion*	1937	200	935,477	110,228	955	14,391	2,785	12	0	0
80	Anse La Butte, *Lafayette, St. Martin*	1902	540	9,904,033	2,661,302		4,745	1,825	98	5	1
81	Arnaudville, *St. Martin*	1943	120	9,015	8,548		202	197	2	1	0
82	Avery Island, *Iberia*	1942	110	785,827	583,286		481	373	10	3	1
83	Bancroft, *Beauregard*	1938	750	3,509,629	184,671		18,887	1,410	43	0	5
84	Barataria, *Jefferson*	1939	270	4,779,906	1,141,741	40	3,304	824	23	0	0
85	Bastian Bay, *Plaquemines*	1941	120	112,678	36,211[17]		693	24	3	0	0
86	Bateman Lake, *St. Mary*	1937	160	1,949,800	347,740	4,640[18]	28,534	9,643	18	3	0
87	Bay Baptiste, *Terrebonne*	1938	0	3,120	0	640	68	0	1	0	0
88	Bay De Chene, *Jefferson, Lafourche*	1941	40	166,876	67,058	160	1,299	26	2	0	0
89	Bay St. Elaine, *Terrebonne*	1934	300	1,059,559	114,837		836	114	17	3	1
90	Bayou Bleu, *Iberville*	1929	540	3,124,865	675,837		809	122	44	1	0

[14] Included under Bethany and Longwood prior to 1941.
[15] Includes Blue Lake.
[17] Includes West Bastian Bay field.
[18] Entire gas area included in cycling operation.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
58	1	0	1	33		Tokio, CreU	S	20	2,600	15	A	Cotton Valley	10,462
				50–65		Cotton Valley, Jur	S	10	8,856	30	A		
						Nacatoch, CreU	S	Por	875	25	A		
59	11	32	0			Tokio, CreU	S	Por	2,450	10	A	Cotton Valley	8,690
						Sligo, CreL	OL	18	5,550	15	A		
60	0	0	6	58		Rodessa, CreL	OL	15	5,500	35	A	Cotton Valley	10,883
61	0	0	2			Rodessa, CreL	OL	17	5,280	12	D	Cotton Valley	10,002
						Hosston, CreL	S	12	6,460	25	D		
						Nacatoch, CreU	S	Por	830	40	Df		
						Ozan, CreU	S	Por	1,600	15	Df		
						Tokio, CreU	S	Por	2,400	10	Df		
						Paluxy, CreL	S	Por	2,640	15	Df		
62	3	62	23	41–43		Morningsport, CreL	L	Por	3,000	10	Df	Hosston	6,122
				57		Rodessa, CreL	OL	15	4,150	30	Df		
				49		Sligo, CreL	OL	17	4,925	50	Df		
						Hosston, CreL	S	Por	5,597[6]	30	Df		
63	0		3	33–43		Wilcox, Eoc	S	26	3,272	51	NL	Midway	5,062
64	0	0	0			Paluxy, CreL	S	Por	2,800	20	A	Hosston	6,063
						Jeter, CreL	OL	Por	4,860	24	A		
65	0	0	0			Paluxy, CreL	S	Por	3,350	5	D	Mooringsport	3,723
66	0	0	3			Wilcox, Eoc	S	Por	2,164[6]	52	Df	U Cretaceous	5,097
						Rodessa, CreL	OL	18	4,300	13	Af		
67	14	0	20	32–37		Sligo, CreL	OL	14	4,900[6]	50	Af	Cotton Valley	10,759
				34		Hosston, CreL	S	25	5,550	18	AFL		
68	2	4	0	28–33		Wilcox, Eoc	S	20	2,512[6]	45	NL	Midway	4,071
69	0	0	0			Paluxy, CreL	S	Por	2,775	10	D	Paluxy	3,003
70	0	0	1	49.4		Cotton Valley, Jur	S	Por	9,060	20	x	Cotton Valley	9,520
71	1	0	0	44		Paluxy, CreL	S	Por	2,732	10	x	L Cretaceous	2,736
72	3	2	0	35–43		Wilcox, Eoc	S	28	3,168[6]	49	NL	Midway	4,810
73	0	199	0	21–22		Wilcox, Eoc	S	Por	1,490	9	NF	Tokio	6,463
						Nacatoch, CreU	S	Por	925	30	A		
74	0	0	3			Tokio, CreU	S	Por	1,875[6]	50	A	Hosston	6,400
						Paluxy, CreL	S	Por	2,540	30	A		
						Hosston, CreL	S	13	6,157	15	A		
75	0	0	0	20		Cockfield, Eoc	S	Por	794	9	NF	Wilcox	2,435
76	2	0	0	37		Wilcox, Eoc	S	Por	5,533	6	NL	Midway	6,810
77	0	40	0	19–38		Wilcox, Eoc	S	28	1,612[6]	190	A	L Cretaceous	8,040
78	0	31	0	42		Annona, CreU	C	Fis	2,100	x	A	Rodessa	6,178
						SOUTH LOUISIANA							
79	3	0	6	50	0.1	MioU	S	26	6,258	141	D	Uvigerina	12,214
				23		Pli	S	Por	1,165	40	Ds		
80	60	8	0	23–40		MioU	S	30	2,800	502	Ds	L Miocene	11,025
				32		MioL	S	25	9,430	58	Ds		
81	2	0	0	38–47		MioL	S	Por	9,914	40	D	L Miocene	10,700
82	9	0	0	32–42.8		MioU	S	Por	8,900	115	Ds	U Miocene	12,005
83	6	15	0	46.7		Cockfield, Eoc	S	28	7,250	15	AF	Wilcox	11,018
84	19	0	1	36–47	0.2	MioU	S	32	7,600	80	D	U Miocene	12,246
85	0	0	0	40		MioU	S	Por	9,350	28	D	U Miocene	10,174
86	4	0	5	33–45		MioU	S	25	8,600	286	D	U Miocene	11,876
87	0	0	0	49		MioU	S	Por	11,200	5	D	U Miocene	13,409
88	1	0	0			Pli	S	Por	2,500	50	Ds	U Miocene	11,436
				33		MioU	S	Por	7,470	30	Ds		
89	6	2	0	29–36		MioU	S	Por	5,600	245	Ds	U Miocene	12,689
90	28	5	1	19–38		MioU	S	Por	1,250	426	Ds	L Miocene	11,049
				34.8		MioL	S	Por	7,388	80	Ds		

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
91	Bayou Bouillion, *St. Martin*	1902	40	430,459	687		102	0	15	0	0
92	Bayou Choctaw, *Iberville*	1931	120	4,138,067	130,314		682	69	23	0	12
93	Bayou Couba, *St. Charles*	1942	200	274,064	204,505		103	82	5	1	0
94	Bayou des Allemands, *St. Charles, and Lafourche*	1937	640	1,235,470	284,432		3,764	928	20	2	0
95	Bayou des Glaises, *Iberville*	1940[19]	40	58,666	54,987		43	43	2	1	0
96	Bayou Mallet, *Acadia*	1936	360	691,990	91,768		1,325	20	8	0	0
97	Bayou Penchant, *Terrebonne*	1944		0	0	320	30	30	1	1	0
98	Bayou Pigeon, *Iberia*	1940	200	843,154	113,317		450	89	5	0	0
99	Bayou Sale, *St. Mary*	1941	2,000	6,110,148	3,111,714		7,044	3,528	45	11	0
100	Bear, *Beauregard*	1943	240	325,670	212,096		459	168	7	1	0
101	Belle Isle, *St. Mary*	1941	50	23,001	17,237	20	733	281	3	2	0
102	Big Lake, *Cameron*	1935	80	105,467	26,616		472	190	2	1	0
103	Black Bayou, *Cameron*	1929	360	11,757,006	1,017,013		3,495	786	41	1	0
104	Bosco-Cankton, *Acadia and St. Landry*	1934	1,600	25,475,113	1,045,920	640	51,583	1,967	72	0	5
105	Branch, *Acadia*	1942	40	96,800	21,570	640	5,218	580	3	1	0
106	Bully Camp, *Lafourche*	1942	160	139,803	139,803[20]	120	173	94	7	5	0
107	Caillou Island, *Terrebonne*	1930	710	37,487,619	1,934,200		6,004	1,635	63	5	1
108	Cameron Meadows, *Cameron*	1931	300	10,258,661	478,927		1,133	105	69	0	0
109	Chacahoula, *Lafourche*	1938	500	3,847,379	939,638	240	3,076	893	43	4	1
110	Chalkley, *Cameron*	1938	2,000	7,116,958	1,248,014		19,753	5,950	39	0	0
111	Charenton, *St. Mary*	1936	830	11,952,113	1,042,749		4,076	392	208	2	0
112	Cheneyville, *Rapides*	1935	640	5,241,315	750,750		17,443	1,807	49	0	0
113	China, *Jefferson Davis*	1940[21]		7,492	382[22]	320	833	11	2	1	0
114	College Point, *St. James*	1944		7,924	7,924	320	228	228	1	1	0
115	Creole, *Cameron*	1938	160	2,371,452	181,763		1,699	282	10	0	0
116	Crowley, *Acadia*	1944				320	0	0	1	1	0
117	Darrow, *Ascension*	1932	175	6,402,418	465,570		2,691	218	23	0	2
118	Deer Island, *Terrebonne*	1942		443	443[23]	800	23	23	2	0	0
119	Delacroix Island, *Plaquemines*	1941	240	384,696	225,958	640	1,248	587	6	1	0
120	Delarge, *Terrebonne*	1938	40	533,417	238,580	640	18,068	7,816	3	1	0
121	Delta Duck Club, *Plaquemines*	1941	280	187,492	122,947		433	285	6	4	0
122	Delta Farms, *Jefferson and Lafourche*	1940	1,520	187,492	2,228,687		5,457	1,914	36	16	0 0
123	Dog Lake, *Terrebonne*	1935	240	3,535,247	390,829		2,315	498	19	2	0
124	East Gibson, *Terrebonne*	1943		12,169	4,423[24]	120	56	50	3	2	0
125	East Hackberry, *Cameron*	1927	940	33,471,649	1,765,414		7,682	1,218	157	2	4
126	East Moss Lake, *Calcasieu*	1944		16,535	16,535	320	270	270	2	2	0
127	East White Lake	1940	680	1,905,965	1,045,463	80	2,408	717	27	10[9]	0
128	Edgerly, *Calcasieu*	1912	215	8,599,625	34,614		0	0	177	0	0
129	Egan, *Acadia*	1943	80	60,225	53,538	960	632	378	5	3	0
130	Eola, *Avoyelles*	1939	2,100	18,207,077	3,161,391		27,587	5,621	102	0	0
131	Erath, *Vermilion*	1940	1,800	4,685,250	4,184,411	2,400[18]	55,057	51,372	61[21]	18	0
132	Fausse Point, *Iberia and St. Martin*	1926	200	673,100	331,725		2,049	649	22	2	2

[19] Discovered in 1940—rediscovered in 1944.
[20] First oil production April 15, 1944.
[21] Includes gas-input wells.
[22] Produced only in December 1944.
[23] Produced only January and February 1944.
[24] Produced January, August, September, October 1944

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
91	0	2	0	20		MioU	S	27	3,200	15	Ds	L Miocene	9,405
						MioL	S	Por	7,480	15	Ds		
92	0	10	0	26		MioU	S	27	2,400	*x*	Ds	L Miocene	10,033
				37		MioL	S	38	7,500	80	Ds		
93	3	0	0	35		MioU	S	Por	6,462	25	Ds	U Miocene	9,759
94	6	5	1	35	0.2	MioU	S	Por	5,425	270	Ds	U Miocene	10,794
95	1	0	0	35.8	0.1	MioL	S	Por	9,840	15	Ds	L Miocene	10,929
96	2	1	2	30		MioL	S	Por	6,380	45	D	Vicksburg	8,408
97	0	0	1	48.8		MioU	S	Por	9,929	10	D	U Miocene	11,828
98	3	0	0	27		MioU	S	30	8,050	20	D	L Miocene	11,934
99	41	0	0	34.7	34.7–50.1	MioU	S	30	4,540	400	D	U Miocene	12,404
100	6	0	0	42.9		MioL	S	Por	6,104	30	D	Cook Mountain	9,414
101	2	0	1	36–47		MioU	S	Por	5,025	36	Ds	U Miocene	12,012
102	2	0	0	39–52		MioU	S	Por	8,571	15	D	L Miocene	13,086
103	17	4	0	22–30	.15	MioU	S	35	4,200	1,200	Ds	L Miocene	8,776
				37–45		MioL	S	35	7,500	360	Ds		
104	27	11	6	38–48		MioL	S, LS	Por	7,900	360	D	Vicksburg	10,434
105	1	0	0	45		MioL	S	Por	9,900	80	D	Vicksburg	10,557
106	4	0	1	33.4		MioU	S	Por	996	250	Ds	U Miocene	11,284
107	41	10	0	35–40		MioU	S	Por	3,700	1,020	Ds	U Miocene	11,289
108	9	20	0	20		Pli	S	Por	1,300	30	Ds	Salt	9,331
				28–42		MioU	S	Por	3,300	150	Ds		
109	20	0	1	34		MioU	S	Por	4,235	230	Ds	L Miocene	10,823
110	26	2	2	36		MioU	S	Por	7,100	160	Ds	L Miocene	11,693
				37		MioL	S	Por	8,400	60	Ds		
111	14	108	0	22–39		MioU	S	Por	950	185	D	U Miocene	10,690
112	7	15	4	44		Cockfield	S	Por	5,350	90	Ds	Wilcox	8,230
				44		Sparta	S	Por	6,150	10	Ds		
113	0	0	0	57		MioL	S	Por	9,175	38	D	Oligocene	10,092
114	0	0	1	48.5		Mio	S	Por	10,660	45	D	L Miocene	10,893
115	7	0	0	34		MioU	S	Por	5,200	70	D	L Miocene	5,989
116	0	0	0	47.5		MioL	S	Por	9,728	12	D	L Miocene	10,000
117	9	6	0	30		MioU	S	25	4,250	268	Ds	L Miocene	10,013
				39		MioL	S	25	8,260	27	Ds		
118	0	0	0			MioU	S	Por	9,565	115	D	U Miocene	11,470
119	5	0	0	36		MioU	S	Por	8,915	90	D	U Miocene	11,165
120	1	0	2	38–51		MioU	S	Por	13,000	80	D	U Miocene	13,586
121	5	0	0	35–56		MioU	S	Por	9,200	141	D	U Miocene	12,010
122	33	0	1	35		MioU	S	Por	8,800	180	D	U Miocene	12,015
123	9	0	0	33–52		MioU	S	Por	6,700	160	Ds	U Miocene	11,648
124	0	0	0			MioU	S	Por	5,870	60	D	U Miocene	10,600
125	27	32	0	27		MioU	S	33	2,700	350	Ds	L Miocene	11,667
				33		MioL	S	Por	6,150	150	Ds		
126	0	0	1	52.2		MioL	S	Por	10,410	10	D	Oligocene	11,325
127	21	0	1	34–40		MioU	S	Por	5,900	180	D	U Miocene	11,163
128	0	10	0	22		MioU	S	Por	3,074	18	Ds	Vicksburg	9,816
129	2	0	3	34–51		MioL	S	Por	10,480	110	D	Vicksburg	11,199
130	47	37	3	36		Cockfield	S	Por	6,400	20	D	Wilcox	11,955
				48		Sparta	S	Por	7,600	20	D		
				42		Wilcox	S	22	8,500	100	D		
131	42	1	3	32–51		MioU	S	29	7,349	1,065	D	U Miocene	12,005
132	7	0	1	35–50		MioU	S	Por	6,640	45	Ds	L Miocene	12,125

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
133	Fields, *Beauregard*	1943		2,713	1,457[26]	160	71	28	1	0	0
134	Four Isle Bay, *Terrebonne*	1935	Abandoned	102,512	0	0	0	0	2	0	0
135	Fresh Water Bayou, *Vermilion*	1942		3,984	3,984	960	103	103	2	1	0
136	Garden Island Bay, *Plaquemines*	1935	500	8,595,912	1,256,427		2,957	631	51	4	0
137	Gibson, *Terrebonne*	1937	740	10,071,462	2,106,205	640	23,662	6,900	32	5	0
138	Gillis-English Bayou, *Calcasieu*	1934	1,200	22,846,562	304,742		36,780	2,384	120	0	17
139	Golden Meadow, *Lafourche*	1938	1,400	20,494,157	2,795,687		10,865	2,188	219	2	15[7]
140	Good Hope, *St. Charles*	1944	120	26,351	26,351		18	18	2	2	0
141	Gordon, *Beauregard*	1944	40	4,597	4,597	320	1,414	1,414	2	2	0
142	Grand Bay, *Plaquemines*	1938	1,400	11,012,024	2,703,995		10,282	2,615	47	5	0
143	Grand Lake, *Cameron*	1939	600	6,175,132	844,916		5,248	905	24	0	0
144	Gueydan, *Vermilion*	1932	400	5,561,439	1,681,315	320	4,769	1,503	37	5	1
145	Gum Cove, *Cameron*	1944		36,966	36,966	320	384	384	3	3	0
146	Happytown, *St. Martin*	1939	80	681,921	114,282		1,328	429	2	0	0
147	Hayes, *Calcasieu*	1942		13,200	2,619	640	871	170	2	0	0
148	Hester (Vacherie), *St. James*	1938	190	171,072	44,490	200	5,334	4,435	10	5	0
149	Hope Villa, *East Baton Rouge*	1943	40	20,606	5,755		9	3	1	0	0
150	Horseshoe Bayou, *St. Mary*	1937	560	2,622,037	401,882	320	4,558	1,384	11	0	0
151	Iberia, *Iberia*	1917	300	32,199,341	2,613,123		6,215	855	122	0	2
152	Indian Village, *Jefferson Davis*	1944	40	8,262	8,262		3	3	1	1	0
153	Iowa, *Calcasieu* and *Jefferson Davis*	1931	1,040	54,981,868	3,307,322		40,994	3,371	99	0	0
154	Jeanerette, *St. Mary*	1935	300	11,432,402	474,963		3,772	437	28	0	1
155	Jefferson Island, *Iberia*	1938	160	1,592,804	177,758		1,487	160	14	0	0
156	Jennings, *Acadia*	1901	800	86,979,372	2,871,213		24,518	2,330	706	1	3
157	Kenilworth, *St. Bernard*	1939	40	132,494	6,968	320	532	6	2	0	0
158	Krotz Springs, *St. Landry*	1942	720	64,206	50,048		969	683	5	4	0
159	Lafitte, *Jefferson Davis*	1935	2,600	40,139,497	4,448,036		40,352	4,189	64	0	0
160	Lafourche Crossing, *Lafourche*	1939		1,350,008	200,377	160	14,290	7,627	7	0	0
161	Lake Arthur, *Jefferson Davis*	1937	280	1,609,948	388,320	1,600	22,784	4,585	16	4	2
162	Lake Barre, *Terrebonne*	1929	500	17,987,043	157,862		928	71	40	0	0
163	Lake Chicot, *St. Martin*	1941	360	1,688,822	769,753	320	1,361	640	15	4	0
164	Lake de Cade, *Terrebonne*	1942	120	55,898	14,178		171	64	2	0	0
165	Lake Hermitage, *Plaquemines*	1934	100	157,754	1,337		81.5	0.2	4	0	0
166	Lake Long, *Lafourche*	1937	1,000	3,979,137	726,515		65,026	18,439	18	0	0
167	Lake Mongoulois, *St. Martin*	1939	80	178,548	36,727	320	7,146	951	4	1	0
168	Lake Pelto, *Terrebonne*	1929	280	3,525,917	640,924		1,546	480	26	3	0
169	Lake Salvador, *St. Charles*	1940	960	3,934,484	1,567,414		2,197	1,364	25	6	0
170	Lakeside (Lowry), *Cameron*	1941		51,508	21,550	480	2,784	1,105	5	1	0
171	Lake Washington, *Plaquemines*	1931	200	3,500,488	149,784		*x*	*x*	7	0	0
172	Lapeyrouse, *Terrebonne*	1941	160	21	21[27]		18	1	1	0	0
173	La Pice, *St. James*	1939	460	882,004	391,769	640	11,224	1,989	11	6	0
174	La Place, *St. John the Baptist*	1938		303,363	28,305	960	16,569	4,638	3	0	0
175	Laurel Ridge, *Iberville*	1944				640	86	86	2	2	0
176	Leeville, *Lafourche*	1931	970	26,824,104	1,427,027	320	5,658	717	141	4	1
177	Lewisburg, *Acadia, St. Landry*	1941		92,409	28,823	960	2,287	776	3	0	0
178	Lirette, *Terrebonne*	1937		686,561	233,368	1,320	44,367	17,510	10	0	3
179	Little Cheniere, *Cameron*	1940		10,079	0	640	*x*	*x*	2	0	0
180	Lockport, *Calcasieu*	1924	720	15,526,317	249,168		3,361	265	80	2	0

[7] Nearest known figure.
[26] Produced only November and December 1944.
[27] Produced only March 1944.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
133	0	0	1	47		Cockfield	S	Por	8,011	18	D	Cane River	10,512
134	0	0	0	44		MioU	S	Por	5,500	35	Ds	U Miocene	10,725
135	0	0	0			MioU	S	Por	11,200	15	D	U Miocene	12,400
136	35	3	1	35		MioU	S	28	4,100	400	Ds	U Miocene	7,898
137	27	0	3	37		MioU	S	32	8,600	230	D	U Miocene	11,440
138	4	18	3	31 36		MioU MioL	S S	Por Por	5,220 6,400	90 120	D D	Oligocene	10,690
139	57	70	3	36		MioU	S	33	2,600	392	D	U Miocene	12,526
140	2	0	0	37		MioU	S	Por	7,800	10	D	U Miocene	10,171
141	1	0	1	24 62		MioU MioL	S S	Por Por	5,319 6,750	7 17		Wilcox	11,541
142	38	0	0	31–39		MioU	S	Por	6,149	250	D	U Miocene	12,034
143	21	0	0	32		MioU	S	Por	8,200	125	D	L Miocene	11,386
144	20	6	2	30 32–60		MioU MioL	S S	Por Por	4,000 9,200	120 250	Ds Ds	L Miocene	11,163
145	0	0	2	55		MioL	S	Por	9,142	8	D	L Miocene	10,242
146	2	0	0	41	.12	MioL	S	Por	9,745	35	D	L Miocene	10,900
147	0	0	0	44		MioL	S	Por	11,620	50	D	L Miocene	11,960
148	3	0	1	36–39 48		MioU MioL	S S	Por Por	5,342 9,340	40 80	Ds Ds	L Miocene	11,415
149	1	0	0	45		MioL	S	Por	9,570	10	D	L Miocene	10,100
150	7	0	1	38–46		MioU	S	Por	10,180	180	D	U Miocene	12,777
151	44	26	0	18 24		Pli MioU	S S	Por 33	800 2,800	50 1,105	Ds Ds	U Miocene	11,408
152	1	0	0	37		MioU	S	Por	7,135	10	D	L Miocene	9,302
153	40	21	2	30 36–58		MioU MioL	S S	Por 30	3,800 7,050	400 350	D D	Vicksburg	9,575
154	10	4	0	35		MioU	S	28	6,400	200	Ds	U Miocene	11,634
155	2	6	0	33		MioU	S	30	3,070	220	Ds	U Miocene	10,402
156	36	65	2	25 38		MioU MioL	S S	Por 28	1,000 5,400	33 500	Ds Ds	Vicksburg	10,766
157	1	0	0	34		MioU	S	Por	10,350	40	D	U Miocene	11,469
158	3	0	1	36–50		MioL	S	Por	9,260	110	D	Eocene	12,298
159	51	5	0	37		MioU	S	29	4,400	320	D	U Miocene	12,115
160	0	0	5	40		MioU	S	31	9,345	15	D	U Miocene	11,000
161	5	0	5	53 41–54		MioU MioL	S S	30 28	8,500 9,500	50 80	D D	L Miocene	12,088
162	2	19	0	30		MioU	S	Por	3,645	50	Ds	Salt	11,333
163	14	0	0	31–60		MioU	S	Por	7,200	120	D	L Miocene	11,980
164	2	0	0	35		MioU	S	Por	10,200	30	D	U Miocene	13,417
165	0	3	0	31	.06	MioU	S	Por	3,190	69	Ds	U Miocene	9,786
166	11	0	7	36–51		MioU	S	Por	9,070	210	D	U Miocene	11,903
167	1	0	1	29–48		MioL	S	33	9,775	60	Ds	L Miocene	11,515
168	13	4	0	43 34		Pli MioU	S S	Por Por	1,350 5,200	25 290	Ds Ds	U Miocene	11,478
169	25	0	0	34		MioU	S	Por	9,600	136	D	U Miocene	11,063
170	0	0	1	50		MioL	S	Por	9,820	150	D	L Miocene	11,059
171	7	0	0	18	.73	Cap Rock	L	Cav	1,150	x	Ds	U Miocene	6,445
172	0	0	0	37		MioU	S	Por	10,900	6	D	U Miocene	10,942
173	8	0	2	39 37–53		MioU MioL	S S	31 Por	6,965 10,018	65 180	D D	L Miocene	11,851
174	0	0	3	54		MioU	S	32	8,100	40	D	L Miocene	11,005
175	0	0	0	50		MioL	S	Por	10,620	20	D	L Miocene	10,846
176	26	42	1	32.5		MioU MioL	S S	Por Por	2,930 11,350	986 40	Ds Ds	L Miocene	12,022
177	2	0	1	53		MioL	S	30	9,090	30	D	Oligocene	10,782
178	0	0	5	51	0.34	MioU	S	Por	8,450	100	D	U Miocene	12,165
179	0	0	0	47		MioU	S	28	10,185	10	D	U Miocene	10,655
180	6	13	1	23 32 41		Pli MioU MioL	S S S	30 30 30	1,000 5,300 6,400	 40	D Ds Ds	Salt	9,569

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
181	Napoleonville, *Assumption*	1943	40	38,289	11,712	320	134	117	2	1	0
182	Neale, *Beauregard*	1940	3,170	5,744,634	2,340,504		7,665	3,334	71[28]	37	0
183	Nibletts, *Jefferson Davis*	1940	Abandoned	5,390	0		4	0	1	0	0
184	North Cankton, *St. Landry*	1944	160	133,705	133,705	320	101	101	5	5	0
185	North Crowley, *Acadia*	1937	670	9,954,261	1,623,937	320	21,651	3,952	46	1	2
186	Northeast Gibson, *Terrebonne*	1941	560	2,573,899	1,433,023	320	1,951	1,100	17	3	0
187	North Elton, *Allen*	1939		93,850	34,204	640	4,715	1,810	4	1	0
188	North Jeanerette, *St. Mary*	1943	40	91,694	52,825		479	301	1	0	0
189	North Richie, *Acadia*	1943	240	105,466	88,074		599	505	6	4	0
190	North Tepetate, *Acadia*	1938	40	299,691	149,046	1,600	10,544	5,396	9	2	0
191	Paradis, *St. Charles*	1939	5,760	11,684,965	4,013,725		10,951	4,044	71	7	0
192	Pecan Island, *Vermilion*	1943		1,975	646[29]	2,660	277	77	3	0	0
193	Pecan Lake, *Cameron*	1941		10,806	3,061	640	386	185	2	0	0
194	Perkins, *Calcasieu*	1939	40	15,074	9,970	640	721	514	4	1	0
195	Pine Prairie, *Evangeline*	1912	1,260	4,503,966	1,951,728	320	4,585	2,395	71	22[30]	0
196	Plumb Bob, *St. Martin*	1939	200	467,969	45,153		217	60	5	1	0
197	Point au Fer, *Terrebonne*	1941		336	0	640	99	0	2	0	1
198	Port Allen, *West Baton Rouge*	1941	240	590,835	120,257		928	128	6	0	0
199	Port Barre, *St. Landry*	1929	555	13,250,899	1,219,346		2,337	699	88	3	3
200	Potash, *Plaquemines*	1937	220	2,935,737	594,652		2,055	683	22	2	0
201	Quarantine Bay, *Plaquemines*	1937	1,860	12,566,513	2,860,260		12,072	3,075	50	4	1
202	Rabbit Island, *Iberia*	1942		691	0	640	56	0	1	0	0
203	Raceland, *Lafourche*	1938	560	3,875,442	729,770	640	11,089	2,845	17	1	0
204	Reddell, *Evangeline*	1943	120			1,280	862	786	6	4	0
205	Richie, *Acadia*	1941	320	804,323	168,869		10	2	14	0	0
206	Roanoke, *Jefferson Davis*	1934	1,280	11,121,447	765,621	640	26,887	3,014	41	6	0
207	Rosedale, *Iberville*	1943	200	71,587	65,849		212	210	5	4	0
208	St. Gabriel, *Iberville*	1941	1,320	5,570,418	1,954,021		3,356	1,774	28	1	0
209	St. James, *St. James*	1943		40,547	35,986	640	1,417	1,256	2	1	0
210	St. Martinville, *St. Martin*	1935	80	1,407,674	55,869	320	512	87	3	1	0
211	Section "28," *St. Martin*	1940	140	108,669	60,704	320	236	42	3	1	0
212	Shuteston, *St. Landry*	1943	40	51,131	36,013	320	310	250	2	1	0
213	Sorrento, *Ascension*	1928	100	1,151,251	26,931		44	2	12	0	0
214	South Crowley, *Acadia*	1938	200	139,288	9,928		146	14	6	0	0
215	South Elton, *Jefferson Davis*	1937		95,708	27,172	640	2,520	649	1	0	0
216	South Houma, *Terrebonne*	1938	80	679,752	38,697	320	3,234	359	3	1	0
217	South Jennings, *Jefferson Davis*	1936		604,710	386,729	1,500	49,680	14,173	8	0	0
218	South Lake Charles, *Calcasieu*	1944		496	496	320	*x*	*x*	1	1	0
219	South Lewisburg, *Acadia*	1943		18,688	17,319	640	1,618	249	2	1	0
220	South Thornwell, *Jefferson Davis*	1942		6,516	4,757	640	402	289	1	0	0
221	Starks, *Calcasieu*	1925	250	3,872,888	197,616		364	330	45	4	0
222	Stella, *Plaquemines*	1940	500	861,611	217,599		748	110	8	0	1
223	Sulphur Mines, *Calcasieu*	1926	200	18,194,446	728,331		1,651	112	133	1	0
224	Sweet Lake, *Cameron*	1926	200	7,453,937	673,364		1,190	72	23	0	0
225	Tepetate, *Acadia*	1935	1,000	13,057,195	730,775		70,631	5,066	60	0	2

[28] Twenty-five dual completions as of 1944.
[29] Produced only March, April and May 1944.
[30] Six dual completions.

TABLE I.—(*Continued*)

Line Number	Wells Producing[p] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[h]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
181	1	0	1	37–54		MioU	S	Por	9,000	22	Ds	U Miocene	11,128
182	59	8	0	45		Wilcox, Eoc	S	Por	8,300	370	D	Cretaceous	12,584
183	0	0	0	42		MioL	S	Por	11,600	16	D	L Miocene	11,748
184	3	0	0	35.5		MioU	S	Por	2,790	10	D	L Miocene	10,512
						MioL	S	Por	9,610	30	D		
185	30	11	1	38	0.17	MioU	S	Por	7,180	26	D	L Miocene	10,652
				36		MioL	S	Por	7,744	100	D		
186	14	0	0	37		MioU	S	32	8,370	220	D	U Miocene	10,535
187	0	0	3	56.4		MioL	S	Por	7,400	15	D	Vicksburg	9,010
188	1	0	0	34		MioU	S	Por	11,457	10	D	U Miocene	12,261
189	6	0	·0	37		MioL	S	Por	8,576	25	D	L Miocene	9,909
190	1	0	7	44–55		MioL	S	30	7,840	113	D	L Miocene	10,368
191	66	0	0	37		MioU	S	25	9,550	300	D	U Miocene	12,133
192	0	0	0	37–50		MioU	S	Por	7,500	160	D	U Miocene	12,057
193	0	0	0	46		MioU	S	Por	8,190	45	D	L Miocene	12,480
194	0	0	2	25		MioL	S	Por	5,367	15	D	Cockfield	9,450
195	53	3	1	40		Cockfield, Eoc	S	Por	7,530	40	Ds	Wilcox	11,694
				40–47		Sparta, Eoc	S	Por	7,875	80	Ds		
						Wilcox, Eoc	S	Por	10,062	250	Ds		
196	3	1	0	34		MioL	S	24	8,256	60	Ds	L Miocene	9,771
197	0	0	0	57		MioU	S	Por	5,608	30	D	U Miocene	11,732
198	3	1	0	33–40		MioL	S	30	9,100	60	D	L Miocene	10,044
199	22	25	0			MioU	S	Por	1,300	*x*	Ds	L Miocene	11,751
				21–60		MioL	S	30	3,100	430	Ds		
				26		Oligocene	S	Por	3,600	20	Ds		
				36		Claiborne, Eoc	S	Por	5,116	20	Ds		
200	14	4	0	28	0.1	MioU	S	Por	688	180	Ds	U Miocene	10,095
201	33	0	0	30		MioU	S	Por	7,690	220	D	U Miocene	11,088
202	0	0	0			MioU	S	Por	8,670	30	D	U Miocene	10,536
203	13	1	1	36		MioU	S	Por	7,200	90	D	U Miocene	12,196
204	3	0	0	57		Sparta, Eoc	S	Por	9,614	80	DF	Wilcox	12,200
205	4	6	0	25		MioU	S	Por	3,500	15	D	L Miocene	9,744
206	15	10	2	33–57		MioL	S	26	6,260	360	D	Vicksburg	10,750
207	3	0	0	34		MioL	S	Por	10,009	22	D	Vicksburg	10,750
208	26	0	0	33		MioL	S	28	7,700	250	D	L Miocene	10,542
209	0	0	2	54		MioL	S	Por	10,700	30	D	L Miocene	11,335
210	2	0	1	31		MioU	S	Por	5,500	50	D	L Miocene	9,968
				51.8		Mio L	S	Por	9,734	30	D		
211	2	0	0	27–47		MioL	S	Por	10,200	120	Ds	L Miocene	11,303
212	2	0	0	39–46		MioL	S	Por	9,495	30	D	Oligocene	11,513
213	4	2	0	23		Pli	S	Por	900	40	Ds	L Miocene	12,038
				24		MioL	S	Por	4,300	20	Ds		
214	1	0	0	29–53	0.1	MioU[31]	S	25	4,364	20	D	Marginulina	10,272
						MioL	S	Por	8,900	70	D		
215	0	0	1	50		MioL	S	30	8,950	30	D	Claiborne	13,210
216	0	0	1	37–52		MioU	S	31	9,750	140	D	U Miocene	11,570
217	0	0	6	50		MioU	S	31	8,600	30	D	Marginulina	10,953
				50		MioL	S	31	8,800	50	D		
218	0	0	1	53.3		MioL	S	Por	10,018	15	D	L Miocene	11,019
219	1	0	0	60		MioL	S	27	10,214	50	D	L Miocene	10,600
220	0	0	1	53		MioL	S	Por	9,625	17	D	L Miocene	10,325
221	4	23	·1	18		Pli	S	Por	570	20	Ds	Oligocene	11,649
				18		MioU	S	Por	740	60	Ds		
				20–55		MioL	S	Por	3,986	150	Ds		
222	5	0	0	40	.12	MioU	S	32	7,000	60	D	U Miocene	10,807
223	6	55	0	27		MioU	S	Por	2,670	20	Ds	L Miocene	7,563
				17–40		MioL	S	Por	4,100	180	Ds		
224	15	1	0	30		MioU	S	Por	5,600	350	D	L Miocene	9,179
225	33	6	4	41		MioU	S	25	8,300	120	D	L Miocene	10,598

[31] Abandoned.

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	Number of Oil and/or Gas Wells: During 1944 Completed	Number of Oil and/or Gas Wells: During 1944 Abandoned
226	Timbalier Bay, *Lafourche*	1938	80	282,225	15,099		36	3	2	0	0
227	University, *East Baton Rouge*	1938	1,100	17,226,707	2,337,105		27,140	4,614	105	4	7
228	Unknown Pass, *Orleans*	1941	Abandoned	9,031	0		52	0	2	0	0
229	Valentine, *Lafourche*	1936	220	5,748,893	186,529		2,266	103	35	0	4
230	Venice, *Plaquemines*	1937	570	9,970,174	3,335,260		8,753	2,966	38	5	0
231	Vermilion Bay, *Iberia*	1939	40	579,206	78,055	320	976	231	4	0	0
232	Ville Platte, *Evangeline*	1937	5,280	29,306,340	3,640,815		197,218	33,848	236[32]	2	0
233	Vinton, *Calcasieu*	1910	1,000	46,137,856	1,952,363		952	754	496	29	5
234	Welsh, *Jefferson Davis*	1902	200	726,970	18,787		1,028	753	171	0	2
235	West Bastian Bay, *Plaquemines*	1944	80	36,211	36,211		693	24	2	2	0
236	West Bay, *Plaquemines*	1940	920	3,114,429	1,061,568		3,519	1,219	25	6	1
237	West Cote Blanche Bay, *St. Mary*	1940	720	2,332,534	745,649		2,114	757	19	1	0
238	West Gueydan, *Vermilion*	1938	460	1,241,105	281,619	640	2,407	1,335	15	4	0
239	West Hackberry, *Cameron*	1927	800	14,068,030	2,341,581	320	7,632	1,331	104	9[33]	0
240	West Lake Verrett, *St. Martin*	1938	960	3,692,132	1,016,244	320	9,243	2,424	34	3	3
241	West Mermentau, *Jefferson Davis*	1940		116,644	75,604	400	4,268	2,052	3	0	0
242	West Tepetate, *Jefferson Davis*	1944	80	22,639	22,639		22	22	2	2	0
243	Westwego, *Jefferson Davis*	1941	120	352,895	96,350		1,873	544	4	0	0
244	West White Lake, *Vermilion*	1943	40	18,099	18,099[34]	320	253	253	3	2[33]	1
245	White Castle, *Iberville*	1929	610	8,819,814	1,445,062		4,745	1,092	31	3	0
246	Woodlawn, *Jefferson Davis*	1938	1,100	5,487,459	964,283	1,000	33,735	6,875	32	0	0

[32] Ten dual completions.
[33] One dual completion.
[34] Initial production June 23, 1944.

total production in the United States. A comparison of production for two years shows that Louisiana produced about ten million more barrels of oil during 1944 than in 1943.

Gas Production

Production of casinghead gas in 1944 amounted to 190,310,000 M cu. ft. and natural gas to 609,210,000 M cu. ft., or a total gas production of 799,521,000 M cu. ft. A comparison of production for the past year with 1943 shows that during 1944 natural-gas production increased by 94,000,000 M cu. ft. and casinghead gas by 6,000,000 M cu. ft. In considering the increased oil production for the state, the increase in casinghead production is by no means excessive.

Gas reserves in Louisiana were considerably increased during 1944 with the finding of such fields as Benton and Spider in north Louisiana and various gas-condensate fields in south Louisiana. Estimates varying from 12 to 15 trillion cubic feet have been given for Louisiana's proven gas reserve.

Completions

Completion records from January to December 1944 show that 733 wells were drilled in or adjoining producing fields. These wells were drilled to deepen or extend producing areas and were definitely on structure. They are not considered as

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
226	0	1	0	27		MioU	S	Por	5,330	30	Ds	Salt	8,727
227	37	22	5	36		MioU	S	35	3,900	100	D	L Miocene	10,362
				43		MioL	S	Por	9,300	150	D		
228	0	0	0	52		MioL	S	Por	9,890	10	D	L Miocene	10,405
229	2	12	0	33		MioU	S	Por	3,800	350	Ds	L Miocene	10,357
230	33	0	0	41		MioU	S	30	3,600	800	Ds	U Miocene	11,402
231	0	1	2	35–50		MioU	S	29	9,300	110	Ds	U Miocene	11,603
232	110	57	16	40–60		Sparta, Eoc	S	21	8,700	60	D	Wilcox	12,527
				36–46		Wilcox, Eoc	S	21	9,600	140	D		
233	40	48	0	22		MioU	S	Por	1,850	135	Ds	Salt	6,939
				31–40		MioL	S	Por	4,700	690	Ds		
234	0	11	1	22		Pli	S	Por	1,200	15	Ds	Hackberry	10,358
				37–49		MioL	S	Por	6,120	110	Ds		
235	2	0	0	34.8		MioU	S	Por	9,158	50	D	U Miocene	11,135
236	20	0	0	34		MioU	S	Por	6,260	200	Ds	U Miocene	11,442
237	12	5	1	21–34		MioU	S	Por	2,000	270	Ds	U Miocene	10,188
238	8	4	1	39–62		MioU	S	Por	6,600	50	D	L Miocene	12,208
				37–40		MioL	S	Por	9,619	190	D		
239	47	28	1	21		MioU	S	25	3,050	39	Ds	L Miocene	10,924
				31		MioL	S	30	4,150	440	Ds		
240	17	9	1	24–37		MioU	S	28	1,300	369	D	U Miocene	11,890
241	0	0	3	47–57		MioL	S	Por	9,100	20	D	L Miocene	10,581
242	2	0	0	32–40		MioL	S	Por	8,516	70	D	L Miocene	10,034
243	4	0	0	36		MioU	S	30	9,000	10	D	U Miocene	11,151
244	1	0	1	37–48		MioU	S	Por	10,660	25	D	U Miocene	12,000
245	12	10	0	28		MioU	S	32	5,150	196	Ds	L Miocene	10,285
				29		MioL	S	Por	9,320	30	Ds		
246	15	2	7	34–51		MioL	S	30	7,480	250	D	L Miocene	10,194

wildcat wells. Of this total number, 438 were completed as oil wells, 135 as gas or gas-condensate wells, and the remaining 160 were dry holes. This means that 78 per cent of the wells were successful compared with 76 per cent of the wells for 1943. A comparison of the total number of field wells drilled during 1944 with the 614 wells that were drilled during 1943 indicates an increase of 19.4 per cent.

New Fields, New Sands, and Extensions

North Louisiana

Six new fields were found in north Louisiana during 1944. In addition, one field that had been abandoned was reopened with the discovery of a new producing zone. The new discoveries, plus the rediscovery, resulted in the finding of three oil fields, three gas-condensate fields, and one gas field. Data available concerning these fields are as follows:

Ada, Webster Parish.—The discovery well found gas condensate at 5465 ft. in the Jeter zone of the Rodessa formation. The open-flow capacity of the well is approximately 12,000 M cu. ft. Productive acreage has been estimated to cover about 2900 acres.

Benton, Bossier Parish.—The discovery well found gas condensate at 8100 ft. in the Bodcaw sand of the Cotton Valley formation. The *D* and *F* sands are also present in this well and show considerable porosity. Other shows were logged at about 6000 ft. in the Travis Peak. A considerable productive section, along with a possibility that the field will cover a large area, recommends this field as a good cycling prospect.

Delhi, Richland Parish.—The discovery well found oil at 3280 ft., in the Tuscaloosa or Paluxy formations. The structure of the field is probably that of a truncated nose forming a stratigraphic trap. Since a considerable unconformity occurs between the truncated beds and the overlying beds, a good possibility exists that a number of sands between the base of the Monroe gas rock and the Paluxy will be productive downdip. This field is the first oil production discovered in northeast Louisiana on the east flank of the Monroe Uplift.

North Holly Ridge, Tensas Parish.—The discovery well found oil at 3000 ft. in the top of the Wilcox formation. Subsequently, dry holes were drilled on all flanks within ¼ mile of the discovery well. This field appears to be of little significance.

Spider, De Soto Parish (Rediscovery).—The discovery well found gas condensate (very lean) at 4875 ft. in the Jeter zone of the Rodessa formation. The open-flow capacity of the well was rated at 125,000 M cu. ft. per day. Data available from shallow wells drilled in the old field indicate that the new production will cover a large area.

Tremont, Lincoln Parish.—The discovery well found gas condensate at 9060 ft. in a sand in the Cotton Valley formation. Additional sands of considerable porosity and thickness are present below the producing zone.

Trenton, De Soto Parish.—The discovery well found oil at 2730 ft. in a sand in the Paluxy formation. The well was completed as a pumper. This discovery appears to represent a minor reserve of little significance.

In north Louisiana 249 field wells were drilled during 1944. Of this number, 107 found oil, 36 found gas condensate, 42 were completed as gas wells in the Monroe field, and 64 were dry. In the process of drilling and completing these wells, two oil sands and two gas-condensate sands, in addition to those already producing, were found and put to production. Important developments in various north Louisiana fields are briefly listed in the following paragraphs:

Athens, Claiborne Parish.—Production extended 4400 ft. northeast.

Bear Creek, Bienville Parish.—Production extended ¾ mile to the east and approximately 1½ miles to the southeast. Oil production (42° A.P.I.) discovered in lower Pettit porosity. Dry test (7990 ft.) was drilled on north flank approximately 4000 ft. north of production.

Bellevue, Bossier Parish.—Dry test (1295 ft.) drilled on southwest flank of field approximately 1½ miles southwest of production.

Caddo, Caddo Parish.—Production extended approximately one mile on south flank. Gas production found on southeast flank.

Calvin, Winn Parish.—Dry test (6102 ft.) drilled approximately 2½ miles northeast of the discovery well. Production in this field is apparently limited to an area within 1½ miles of the discovery well.

Cotton Valley, Webster Parish.—New gas-condensate sand found at 10,650 ft. (Smackover) in well completed in approximately the center of the field. Production from the Bodcaw sand approximately 2½ miles north of the formerly established limits is now recognized to be connected with Cotton Valley field proper and has been included in the Cotton Valley cycling unit.

East Nebo, La Salle Parish.—Wilcox production extended ½ mile west of discovery well. Dry test (4387 ft.) drilled 3000 ft. northwest of the discovery well. Previous tests have defined the field to the north and east.

Greenwood, Caddo Parish.—Dry test (6431 ft.) drilled approximately ½ mile northwest of the discovery well. Field previously defined on the north, west, and southwest.

Haynesville, Claiborne Parish.—New deep oil sand found at 8835 ft. in the Cotton Valley formation. Pettit production extended 1600 ft. on southwest flank and ¼ mile on south flank. Entire Pettit reservoir has been pooled and unitized for the purpose of pressure maintenance. Dry test (5565 ft.) drilled 1800 ft. south of production on southeast flank apparently limiting southeastward extent of porosity.

Holly, De Soto Parish.—Nineteen dry tests have defined the field on all flanks except the southwest flank. Twenty-one producers (mostly on pump) were completed in the field, making it one of the most active in north Louisiana during the past year.

Holly Ridge, Tensas Parish.—Production extended ½ mile or more in all directions except on the north and west flanks. Two dry tests (8436 and 10,022 ft.) were drilled ¼ and ½ mile, respectively, north of the discovery well. This field was one of the most active in north Louisiana, with 23 completions in 1944.

Homer, Claiborne Parish.—Dry test (6884 ft.) drilled on south flank of the structure near edge of shallow production. Eagle Mills salt was topped at 6862 ft.

Lake St. John, Concordia and Tensas Parishes. Production established between the North Lake St. John and Lake St. John fields, indicating a structure at least 5½ to 6 miles long. Only Tuscaloosa and deeper horizons are productive throughout the entire structure. Seventeen wells were completed during 1944.

Logansport, De Soto Parish.—Production extended approximately ½ mile on southeast flank.

Lucky, Bienville Parish.—Production extended approximately 3¼ miles northwest and 4 miles southeast of the discovery well. Available data indicate the field will cover a considerable area.

Nebo-Hemphill, La Salle Parish.—Production extended approximately ¼ mile on northwest and southeast flanks. Dry test (4330 ft.) drilled on north flank 1800 ft. from production apparently defining field on the north.

Northeast Lisbon, Claiborne Parish.—New gas-condensate sand (Bodcaw) found at 7800 ft. Hosston production extended approximately 4000 ft. on southeast flank. Dry test (7917 ft.) drilled on northeast flank 3000 ft. from production.

Olla, La Salle Parish.—Dry test (8320 ft.) drilled in approximately the center of the field.

Ruston, Lincoln Parish.—Northwest Ruston and Ruston fields connected through completion of a producing well midway between the two fields. Production also extended one mile east of the North Ruston discovery well. Dry test (5806 ft.) drilled on west flank approximately one mile west of production. A considerable gas-condensate reserve is now indicated for this field.

Tullos-Urania, Grant and La Salle Parishes.—Dry test (4851 ft.) drilled on southeast flank of Urania field approximately 1½ miles from production.

Zenoria-Little Creek, La Salle Parish.—Dry test (2607 ft.) drilled on west flank ¼ mile from production. Dry test (8040 ft.) drilled on east flank one mile east of production.

South Louisiana

Thirteen new fields were found in South Louisiana during 1944. In addition, two fields that had been abandoned were reopened with the discovery of new producing sands. These new discoveries and rediscoveries resulted in the finding of six oil fields and nine gas-condensate fields. Data available concerning these fields are as follows:

Bayou des Glaises, Iberville Parish (Rediscovery).—Original production was from a depth of 8600 ft. Field produced from April to August 1940 and was then abandoned. The rediscovery well found oil at 9840 ft. on the northwest flank of the dome approximately one mile northwest of the former production. An effective sand thickness of at least 15 ft. was found in the new well. This new discovery will undoubtedly lead to considerable drilling activity around the outer flanks of the dome. (Shallowest salt top 3697 ft.)

Bayou Penchant, Terrebonne Parish.—The discovery well found gas condensate at 9900 ft. in a sand of Upper Miocene age. The liquid content of the gas is very lean and, for all practical purposes, the field must be viewed as a gas field.

China, Jefferson Davis Parish (Rediscovery). This field was discovered in 1940 and produced gas condensate from a sand at 9300 ft. The discovery well was shut in and finally was abandoned in 1942. In 1941 a dry test (9965 ft.) was drilled approximately ½ mile south of the original discovery well. The rediscovery well, completed in 1944, was drilled approximately ¾ mile northeast of the first producing well, or approximately midway between the latter and a series of dry tests drilled on the north flank prior to 1940. The rediscovery well found gas condensate in a Lower Miocene sand at 9200 ft. This field apparently will merit further development as a cycling prospect.

College Point, St. James Parish.—The discovery well found gas condensate at 10,750 ft. in a sand of Lower Miocene age. This discovery, in all probability, is north flank pro-

TABLE 2.—*Wildcat Wells Completed in Louisiana in* 1944

Line No.	Parish and Operator	Lease and Well Number	Location			Total Depth, Ft.	Completion Date	Deepest Horizon Tested	Remarks
			Sec.	Tp.	Rge.				
	NORTH LOUISIANA								
	Bienville Parish								
1	G. H. Pierce and R. H. Crow	E. W. Merritt No. 2	13	17 N	7 W	3,690	11-14-44	CreU	Approximately midway between Bear Creek field and Gibsland dome
	Bossier Parish								
2	D. C. Richardson, Jr. .	J. T. Wurtsbaugh No. 1	25	19 N	11 W	6,629	3- 2-44	Hosston	1½ miles southeast of Bellevue field
3	J. C. Robbins and Lewis	Ellerbe No. 1	3	20 N	13 W	5,550	3-10-44	CreL	Temporarily abandoned
4	J. R. Hayden, Jr.......	Ellerbe No. 1	3	20 N	13 W	6,027	3- 7-44	CreL	Temporarily abandoned
5	Beene and Earhardt...	Fenet No. 2	24	21 N	14 W	917	1-22-44	Nacatoch	On east flank of Pine Island field
6	O. F. Shaver..........	Gaines No. 1	8	21 N	13 W	1,340	7-21-44	Nacatoch	6 miles east of Pine Island field
7	O. F. Shaver..........	W. M. Broom Fee No. 1	8	21 N	13 W	1,380	10-20-44	Nacatoch	6 miles east of Pine Island field
8	H. H. Temple........	Pirkle No. 1	31	19 N	12 W	1,864	12-28-44	Annona	Midway between Shreveport and Bellevue fields
	Caddo Parish								
9	Ohio Oil Co..........	R. W. Williams No. 1	3	22 N	15 W	5,933	1- 6-44	Sligo	Pettit test on north flank of Caddo-Pine Island structure
10	O. R. Pennington....	Jacob Grenburg No. 1	9	15 N	15 W	1,170	5-26-44	CreU	Temporarily abandoned
11	Conway Oil Co........	Thigpen-Harold-Lane No. 2	5	19 N	16 W	3,000	10-12-44	Pine Island	On southwest flank of Caddo-Pine Island field
12	O. R. Pennington.....	Duke Williams No. 1	3	15 N	15 W	5,204	6-30-44	Rodessa	
	Caldwell Parish								
13	Atlantic Ref. Co......	La. Cent. Lbr. Co. No. 1	6	13 N	2 E	6,275	9- 7-44	Salt	Chester salt dome—discovery well—top salt 5045 ft.
14	Northern Ordnance....	C. McMullen No. 1..	20	13 N	2 E	9,736	7-10-44	CreL	Flank test on Chester salt dome—base of Ferry Lake 8105 ft.
15	Atlantic Ref. Co......	La. Cent. Lbr. Co. No. B-1	5	11 N	3 E	5,048	12- -44	CreU	3 miles north of Standard field
	Catahoula Parish								
16	Jos. F. Belt..........	Mrs. A. A. Webb No. 1	3	8 N	5 E	423	6-17-44	Catahoula	3 miles south of Manifest field
17	Sinclair Oil Co........	Mrs. A. A. Webb No. 1	10	8 N	5 E	5,650	12-12-44	Midway	Wilcox test 3 miles south of Manifest field
18	Sinclair Oil Co........	Gabe Fisher No. 1	26	9 N	6 E	5,814	11- 7-44	Midway	Wilcox test on Wallace Ridge prospect
	Claiborne Parish								
19	Big West Drill. Co....	Mrs. Rainach No. 1	16	22 N	5 W	8,000	4- 2-44	Cotton Valley	
	Concordia Parish								
20	Royal Petr. Co.......	Canebrake No. 1	1	8 N	10 E	9,659	4-10-44	CreL	Tuscaloosa test on the southeast flank of Lake St. John field
	De Soto Parish								
21	Superior Oil Co.......	Mansfield Hardwood Lbr. Co. No. 1	24	11 N	11 W	6,503	2-18-44	Pine Island	3 miles south of Red River-Bull Bayou field
22	Milton J. Houston et al	Dorothy L. Nickey No. 1	1	13 N	13 W	2,915	9-15-44	Paluxy	3 miles east of Holly field
23	M. M. Brush..........	Peck No. 1	25	11 N	13 W	2,010	3- 1-44	Tokio	
24	Q. M. McCullough....	Kavanaugh No. 1	18	11 N	11 W	3,002	11-15-44	Paluxy	On south flank of Red River-Bull Bayou field
25	H. C. McCalman......	Williams No. 1	6	10 N	12 W	1,905	6-23-44	Tokio	2½ miles east of Benson field
26	C. W. Beene..........	W. F. Williams No. 1	25	15 N	15 W	1,169	8-21-44	Nacatoch	
27	G. C. Schoonmaker....	Sample No. 1	12	13 N	14 W	2,900	10- 6-44	Tokio	1 mile west of Holly field
	East Carroll Parish								
28	Placid Oil Co.........	Marie Milliken No. 1	22	23 N	12 E	5,191	3-30-44	Cotton Valley	Jurassic test on "Sharkey platform"
	Franklin Parish								
29	C. L. Smith..........	Bates Estate No. 1	18	12 N	8 E	7,513	7-31-44	CreL	
30	Marr, Collins and Titantic Oil	J. H. Baker No. 1	26	16 N	9 E	7,113	3-23-44	Rodessa	6 miles south of Delhi field
31	C. L. Smith..........	J. B. Eley No. 1	25	13 N	7 E	6,770	12-14-44	CreL	

TABLE 2.—(*Continued*)

Line No.	Parish and Operator	Lease and Well Number	Location Sec.	Tp.	Rge.	Total Depth, Ft.	Completion Date	Deepest Horizon Tested	Remarks
	Grant Parish								
32	Calapor Mfg. Co.	Edenborn No. 1	20	7 N	3 W	4,538	11- 6-44	Wilcox	
33	H. H. Temple	N. N. Homer No. 2	38	6 N	2 W	2,200	10-13-44	Sparta	
	La Salle Parish								
34	Placid Oil Co.	Tremont Lbr. Co. No. F-1	14	9 N	2 E	12,000	7-17-44	CreL	On southern tip of Olla field
35	Atlantic Ref. Co.	Q. T. Hardtner No. 1	3	10 N	2 E	3,939	10-26-44	Midway	2 miles northwest of Olla field
36	Harry Shullman	Whidden No. 1	9	9 N	3 E	224			Temporarily abandoned
	Lincoln Parish								
37	S. W. Gas Prod. Co.	V. W. Colvin Heirs No. 1	7	19 N	2 W	6,100	9-22-44	Hosston	2 miles north of Ruston field
	Madison Parish								
38	C. H. Murphy, Jr.	E. Sondheimer Co. No. 1	10	17 N	12 E	4,470	2-17-44	CreL	
	Morehouse Parish								
39	Roeser and Pendleton	Taylor No. 1	1	21 N	7 E	6,602	3-25-44	Smackover	East side of Monroe uplift
40	The Texas Co.	Louisville Cooperage No. 2	36	23 N	8 E	4,917	7-29-44	Cotton Valley	East side of Monroe uplift
41	The Texas Co.	Annie Kimball No. 1	3	23 N	9 E	5,036	10- 9-44	Smackover	East side of Monroe uplift
42	The Texas Co.	Mrs. Susie R. Kennedy No. 1	32	22 N	6 E	6,459	12- 6-44	Smackover	3 miles east of Monroe field
	Natchitoches Parish								
43	J. M. Breedlove	Adrian Land No. 1	2	11 N	8 W	3,450	4-21-44	Tokio	
44	C. H. Bigsby	Jorda and Lilly No. 1	28	9 N	10 W	4,200	3-25-44	Paluxy	
	Ouachita Parish								
45	Kingwood Oil Co.	Pardee No. 1	10	16 N	3 E	6,364	6-10-44	Travis Peak	South side of Monroe uplift
46	Westgate Greenland Oil Co.	Louis Werner Sawmill Co. No. 2	9	17 N	2 E	6,052	7-29-44	Rodessa	South side of Monroe uplift
	Richland Parish								
47	Humphrey and Wynne	D. R. Sartor No. 1	27	15 N	6 E	4,408	10- 5-44	CreL	5 miles south of Richland field
	Sabine Parish								
48	Lyons and Prentiss	La. Long Leaf Lbr. Co. No. 1	25	6 N	12 W	4,116	8-12-44	Eagleford	
49	Lyons and Prentiss	La. Long Leaf Lbr. Co. No. 2	23	6 N	13 W	3,638	8-26-44	Annona	
	Tensas Parish								
50	Chicago Mill and Lbr. Co.	Mutual No. 1-A	30	12 N	10 E	8,306	9-17-44	Tuscaloosa	4 miles north of Holly Ridge field
51	David M. Lide	David M. Lide, No. 1	22	12 N	12 E	9,747	4- 5-44	L. Cret.	
52	Placid Oil Co.	Ayer Timber No. 1	18	14 N	11 E	9,770	3- 6-44	Mooringsport	
53	Sohio Prod. Co.	Penrod-Jorden No. 1	8	11 N	10 E	8,479	2-15-44	Tuscaloosa	1 mile northeast of Holly Ridge field
	Union Parish								
54	Westgate Greenland Oil Co.	Frost Ind. Inc. No. 1	26	22 N	1 E	5,033	1-18-44	L. Cret.	
55	Sohio Prod. Co.	Vashti E. Moore No. 1	2	22 N	2 E	7,985	4-22-44	Smackover	
56	H. J. Strief	Frost Lbr. Ind. No. 1	23	23 N	2 W	3,596	11-27-44	L. Cret.	
	Webster Parish								
57	W. E. Stewart	Woodward and Walker No. 1	9	17 N	8 W		2-12-44		
58	Phillips Petr. Co.	Docia No. 1	18	22 N	9 W	8,743	12-21-44	Cotton Valley	Midway between Cotton Valley and Shongaloo fields
	West Carroll Parish								
59	Pure Oil Co.	Letha Sanders Costello No. 1	27	23 N	10 E	5,500	8-27-44	Jurassic	On east side of Monroe uplift
60	California Co.	Sam C. Jackson No. 1	24	22 N	10 E	3,357	4-19-44	Igneous	On east side of Monroe uplift
	SOUTH LOUISIANA								
	Acadia Parish								
61	Continental Oil Co.	C. T. Duhon No. 1	36	10 S	2 W	11,607	1- 1-44	MioL	2 miles east of West Mermentau field
62	The Union Sulphur Co.	Edward E. Daigle No. 1	49	7 S	2 E	11,232	5-27-44	MioL	3 miles west of South Lewisburg field
	Ascension Parish								
63	R. Y. Walker and Calapor Mfg. Co.	Realty Operators No. 1	1	11 S	3 E	11,227	10-27-44	MioL	5¼ miles southeast of Darrow field

TABLE 2.—(*Continued*)

Line No.	Parish and Operator	Lease and Well Number	Location Sec.	Location Tp.	Location Rge.	Total Depth, Ft.	Completion Date	Deepest Horizon Tested	Remarks
	Assumption Parish								
64	Shell Oil Co., Inc.	St. Lse. No. 346 Lake Verret No. 1	30	13 S	13 E	12,514	3-18-44	MioU	4½ miles northeast of West Lake Verret field
65	Phillips Petr. Co.	Amelia No. 1	13	16 S	13 E	12,020	5- 4-44	MioU	Midway between Bateman Lake and Chacahoula fields
66	Humble Oil & Ref. Co.	Alfred Robichaux et al. No. 1	100	14 S	15 E	11,790	5- 2-44	MioU	8 miles north of Chacahoula field
	Beauregard Parish								
67	Sun Oil Co.	Central Coal and Coke Corp. No. 2	30	3 S	11 W	4,440	3-11-44	Vicksburg	Hole junked
68	Sun Oil Co.	Central Coal and Coke Corp. No. 2-A	30	3 S	11 W	10,618	7-29-44	Wilcox	1 mile west of the Neale field
69	Magnolia Petr. Co.	Lutcher Moore Lbr. Co. No. 1	22	6 S	11 W	12,325	4- 8-44	Wilcox	Northeast flank of Oretta prospect
	Cameron Parish								
70	Duval Texas Sulphur Co.	St. Lse. No. 50 Calcasieu Lake No. 1		13 S	9 W	2,094	1- 7-44	Cap rock	Sulphur test on Calcasieu Lake dome
71	The Pure Oil Co.	St. Lse. No. 549 Snake Lake No. 1	26	13 S	3 W	10,863	2-12-44	MioU	4 miles southeast of Grand Lake field
72	Duval Texas Sulphur Co.	St. Lse. No. 50 Calcasieu Lake No. 2		13 S	9 W	2,225	3-11-44	Cap rock	Sulphur test on Calcasieu Lake dome
73	Humble Oil and Ref. Co.	Cameron Par. Sch. Bd. No. B-1	16	14 S	5 W	10,225	6-12-44	MioU	2½ miles southeast of Little Cheniere field
74	Continental Oil Co.	A. B. McCain Est. No. 1	21	12 S	8 W	9,653	6-26-44	MioL	2 miles southeast of Big Lake field
75	Continental Oil Co.	St. Lse. No. 50 Calcasieu Lake No. 1	1	14 S	9 W	7,791	7-15-44	MioU	Southeast flank test of Calcasieu Lake dome
76	Amerada Petr. Corp.	Glassell et al. No. 1		13 S	3 W	9,634	8-12-44	MioU	1 mile east of Grand Lake field
77	Humble Oil and Ref. Co.	St. Lse. No. 568 Rockfeller Preserve No. 1	30	16 S	3 W	12,003	9- 9-44	MioU	First test drilled on Rockfeller preserve
78	Stanolind Oil and Gas Co.	Joseph Bishop No. 1	5	15 S	8 W	9,472	11-16-44	MioU	2 miles northwest of Creole field
	East Baton Rouge Parish								
79	R. Y. Walker and Calapor Mfg. Co.	Ropollo Community No. 1	53	7 S	1 E	10,012	7-30-44	MioL	3 miles east of University field
	Evangeline Parish								
80	Danciger Oil and Ref. Co.	Bowman Hicks Lbr. Co. No. 1	4	3 S	2 W	9,764	1-28-44	Wilcox	8 miles northwest of Pine Prairie field
	Iberia Parish								
81	Phillips Petr. Co.	M. A. Stewart No. 1	42	12 S	7 E	12,503	1-17-44	MioU	2 miles southeast of Iberia field
82	Tide Water Assoc. Oil Co.	Miami Corporation No. 1	9	15 S	6 E	11,990	5-20-44	MioU	5½ miles northwest of West Cote Blanche field
83	The Texas Co.	St. Lse No. 334 Vermilion Bay No. C-2		14 S	5 E	11,886	8- 4-44	MioU	In northeast Vermilion Bay area, 2nd test
84	The Pure Oil Co.	L. L. Trahan No. 1	9	12 S	6 E	12,536	12- 2-44	MioU	Midway between Jefferson Island and New Iberia fields
	Iberville Parish								
85	Humble Oil and Ref. Co.	Federal No. 1	1	11 S	13 E	11,915	4-10-44	MioL	Laurel Ridge prospect
86	Sugar Field Oil Co. Inc.	Schwing No. 1	62	7 S	9 E	11,454	6- 2-44	Cockfield	1¼ miles west of the Rosedale field
	Jefferson Parish								
87	The Texas Co.	E. P. Brady No. 1	65	16 S	24 E	10,985	3-27-44	MioU	4 miles northeast of Barataria field
	Jefferson Davis Parish								
88	Barnsdall Oil Co.	J. Fuselier No. 1	31	7 S	2 W	9,580	4- 5-44	MioL	2 miles west of Tepetate field
	Livingston Parish								
89	Sugar Field Oil Co. Inc.	Evans No. 1	49	8 S	3 E	9,871	4-14-44	MioL	2½ miles east of Hope Villa field
	Orleans Parish								
90	W. T. Burton	St. Lse. No.318 No. 10	10	11 S	14 E	2,080	10- 6-44	Pliocene	In Lake Pontchartrain, 5½ miles west of Unknown Pass field
	Plaquemines Parish								
91	The Texas Co.	La. Citrus Lands Co. No. 1	16	16 S	24 E	11,083	5-10-44	MioU	5 miles northeast of the Lafitte field

TABLE 2.—(*Continued*)

Line No.	Parish and Operator	Lease and Well Number	Location			Total Depth, Ft.	Completion Date	Deepest Horizon Tested	Remarks
			Sec.	Tp.	Rge.				
	Rapides Parish								
92	Claude Morgan	Irene Wettermark No. 1	24	5 N	3 W	7,000	10-13-44	Midway	Northern Rapides Parish
93	La. Ld. and Exploration Co.	Bentley Trust No. 2 et al. No. A-1	25	5 N	5 W	7,200	12-18-44	Midway	Northern Rapides Parish
94	J. P. Perry	Perry McGinty No. 1	5	4 N	3 E	5,631	4-10-44	Wilcox	Spudded 7-19-42
	St. Mary Parish								
95	The Texas Co.	St. Lse. No. 340 Cote Blanche Island No. 5		15 S	8 E	11,515	1-23-44	MioU	On southeast flank of Cote Blanche Island dome
96	The Texas Co.	St. Lse. No. 340 Cote Blanche Island No. 6		15 S	7 E	9,420	9-22-44	MioU	On southwest flank of Cote Blanche Island dome
97	The Texas Co.	St. Lse. No. 340 Point Marone No. 1		16 S	8 E	11,516	4-20-44	MioU	In east side of West Cote Blanche Bay
98	Humble Oil and Ref. Co.	Miami Corp. "F" No. 1		15 S	8 E	12,041	11- 3-44	MioU	
	Tangipahoa Parish								
99	Humble Oil and Ref. Co.	Jos. Rathbone Ld. Co. No. 1	25	7 S	7 E	9,314	4-24-44	MioL	
100	Humble Oil and Ref. Co.	Williams, Inc. No. 1	31	7 S	8 E	9,229	9-15-44	MioL	
	Terrebonne Parish								
101	Gulf Ref. Co.-Gulf Prod. Div.	South Shore Oil and Dev. Co. No. 1	28	17 S	18 E	12,022	2- 3-44	MioU	4 miles west of Lake Long field
102	Arkansas Fuel Oil Co.	La Terre Co. No. 1	1	19 S	13 E	11,327	3-20-44	MioU	1½ miles south of Bayou Penchant field
103	Sun Oil Co.	Blanchard Pool No. 1	43	17 S	16 E	11,015	11- 3-44	MioU	3½ miles east of Gibson field
104	La. Ld. and Exploration Co.	L L & E "Fee" No. 1	8	20 S	13 E	12,010	11-19-44	MioU	First drilling in Four League Bay area
	Vermilion Parish								
105	Phillips Petr. Co.	F. A. Godchaux No. 1	88	14 S	3 E	12,527	2-21-44	MioU	On northeast flank Intercoastal City prospect
106	The Texas Co.	St. Lse. No. 340 Vermilion Bay No. D-1		15 S	4 E	11,649	4-17-44	MioU	In west side of Vermilion Bay
107	Phillips Petr. Co.	Vermilion Dev. Co. No. 1	90	14 S	3 E	12,497	6- 7-44	MioU	On west flank of Intercoastal City prospect
108	Magnolia Petr. Co.	Fisher Estate No. 1	39	12 S	2 W	10,839	8- 5-44	MioL	East flank of West Gueydan field

duction on the College Point-St. James structure or dome.

Crowley, Acadia Parish.—The discovery well found gas condensate at 9700 ft. in a sand of Lower Miocene age. This discovery is approximately 1¼ miles northwest of the South Crowley field and strongly suggests a structural relationship.

East Moss Lake, Calcasieu Parish.—The discovery well found gas condensate at 10,400 ft. in a sand of Lower Miocene age. Subsequent to the discovery well, the field was extended ½ mile westward. These wells have also encountered other probable productive sands. The gas-liquid ratio of the presently producing sand is comparatively low suggesting cycling operations to secure maximum recoveries with a minimum number of wells.

Good Hope, St. Charles Parish.—Discovery well found oil at 7830 ft. in a sand of Upper Miocene age. Subsequently another well was completed in the same sand approximately ½ mile west of the discovery well. The limited data available indicate that this field will develop into a major oil discovery.

Gordon, Beauregard Parish.—The discovery well found gas condensate at 6760 ft. in a sand of Lower Miocene age. Gas sands were also logged in this well at 5050 ft., 5175 ft., 5280 ft., 6700 ft., and 6750 ft. The second well was completed in an oil sand at 5320 ft. approximately ½ mile east of the discovery well. Three tests, one of which was completed in 1941 prior to the discovery well, have been drilled at locations ranging from ½ to one mile north and east of the second well.

Gum Cove, Cameron Parish.—The discovery well found gas condensate at 9145 ft. in a sand of Lower Miocene age. Subsequently an oil sand was found at 9550 ft. in a well approxi-

mately ¼ mile southwest of the discovery well and at 9650 ft. in a well approximately ¼ mile northwest of the discovery well. Production, to a certain extent, has been defined by a dry test drilled in 1943 (10,808 ft.) ¼ mile north of the discovery well.

Indian Village, Jefferson Davis Parish.—The discovery well found oil at 7135 ft. in a sand of Lower Miocene age.

Laurel Ridge, Iberville Parish.—The discovery well found gas condensate at 10,685 ft. in a sand of Lower Miocene age. The second well, 6500 ft. southeast of the discovery well, found a second gas-condensate sand at 10,620 ft. This field may develop eventually into a considerable gas-condensate reserve.

North Cankton, St. Landry Parish.—Discovery well found oil at 9665 ft. in a sand of Lower Miocene age. Production has been extended approximately 3100 ft. to the northwest and ¼ mile to the south and southwest. Shallow gas sand was found at 2800 ft. in a well 4800 ft. northwest of the discovery well. Available data indicate that sands at 9400 ft., at 9800 ft., at 10,100 ft. and 10,200 ft. are capable of producing gas. Additional exploration may reveal that this field will be more important as a gas-condensate reserve than as an oil reserve.

South Lake Charles, Calcasieu Parish.—The discovery well found gas condensate at 9665 ft. in a sand of Lower Miocene age. Prior to the discovery well, dry tests were drilled approximately ⅔ mile west of the discovery well and slightly less than one mile east of it. The comparatively low gas-liquid ratio suggests that this field may be a possible cycling prospect.

West Tepetate, Jefferson Davis Parish.—The discovery well found oil at 8515 ft. in a sand of Lower Miocene age. The second well, approximately 900 ft. east of the discovery well, completed in a new oil sand found at 9165 ft. Available data indicate that at least five sands are capable of producing oil in the field. All sands are very thick, indicating that the field is one of the major discoveries in south Louisiana for 1944.

West Bastian Bay, Plaquemines Parish.—The discovery well found oil at 9165 ft. in a sand of Upper Miocene age. The second well extended the field approximately ¼ mile west. Two dry tests have been drilled 1900 ft. northeast and ¼ mile east of the discovery well. The producing sand is very thin and no considerable reserve is indicated.

During the year, 484 field wells were drilled in south Louisiana. Of this number, 331 were completed as oil wells, 57 as gas-condensate wells, and 96 were dry In the process of drilling and completing these wells, 40 oil sands and 12 gas-condensate sands, in addition to those already producing, were found and put to production. Seven fields that formerly were classified as gas-condensate fields found and produced oil sands for the first time. Important developments in various south Louisiana fields are briefly listed in the following paragraphs:

Abbeville, Vermilion Parish.—Dry test well (6437 ft.) drilled on east flank.

Arnaudville, St. Martin Parish.—New gas-condensate sand found at 9900 ft. in well 3000 ft. north of discovery well. Dry test (10,504 ft.) drilled on east flank 2800 ft. east of discovery well.

Anse la Butte, Lafayette, St. Martin Parishes.—New oil sand found at 11,000 ft. on northwest flank of dome extending production one mile west of previous production.

Avery Island, Iberia Parish.—Two new oil sands found at 9400 and at 10,200 ft. on west flank of dome extending production approximately ½ mile northward along west flank. Dry test (9807 ft.) on southwest flank of dome, ½ mile southeast of discovery well.

Barataria, Jefferson Parish.—Dry test (11,102 ft.) drilled on southeast flank approximately one mile from production.

Bateman Lake, St. Mary Parish.—Gas-condensate production extended ½ mile on northeast and east flanks. Oil production extended ½ mile on southwest flank. All gas-condensate sands have been pooled and unitized for the purpose of cycling. Present cycling capacity to be increased to 70 million cubic feet of gas per day.

Bayou Bleu, Iberville Parish.—New oil sand found at 7400 ft. on northeast flank of dome. This new deep production is approximately one mile north of shallow production.

Bayou Couba, St. Charles Parish.—New oil sand discovered at 8000 ft. on southeast flank

extending the producing area approximately 1400 ft. southward. Dry test (9759 ft.) drilled on southeast flank approximately ½ mile south of production.

Bayou des Allemands, St. Charles, Lafourche Parishes.—Production extended 4800 ft. on south flank.

Bayou des Glaises, Iberville Parish.—Field abandoned in 1941. New oil sand found at 9800 ft. on north flank of dome approximately one mile northwest of abandoned area during the past year has renewed activity in this field.

Bayou Sale, St. Mary Parish.—Two dry tests (10,471 and 10,114 ft.) drilled on southwest flank approximately ½ mile southwest of production. However, one additional well was completed on southwest flank approximately ½ mile southwest of the dry holes, indicating an offset fault block. Production extended approximately ¼ mile on the south and east flanks. Production limited in the central part of the field by two dry tests (10,500 ft. and 11,250 ft.).

Bay St. Elaine, Terrebonne Parish.—Two new oil sands found at 9000 ft. and 10,200 ft. on northwest flank of dome, approximately 2 miles north of previous production.

Bear, Beauregard Parish.—Production defined on southwest flank by dry test (6575 ft.).

Belle Isle, St. Mary Parish.—Two new oil sands found at 5000 and 8200 ft. on southwest flank of dome. Previous production in this field was gas condensate. New oil production limited on southwest by dry test (9431 ft.) drilled 660 ft. southwest of production. Dry test also drilled on south flank of dome and abandoned in salt at 7535 ft. (Top salt 7530 ft.).

Big Lake, Cameron Parish.—Producing area extended one mile northwest of rediscovery well.

Black Bayou, Cameron Parish.—Production extended southwestward to west flank of dome. Two dry tests drilled on northeast flank and abandoned in salt at 5266 ft. and 6805 ft. Salt top found in one well at 5231 ft. and in other at 6785 feet.

Branch, Acadia Parish.—New gas-condensate sand found at 11,100 ft. on south flank of dome, 1800 ft. south of previous production.

Bully Camp, Lafourche Parish.—Two new oil sands found at 6400 and 6500 ft. Production extended ½ mile on north flank and one mile on southeast flank.

Caillou Island, Terrebonne Parish.—Deep production extended ¼ mile northward on west flank. East flank production (deep) extended ½ mile to the north and south. Dry test (10,558 ft.) on southwest flank 1500 ft. southwest of gas-condensate production.

Chacahoula, Lafourche Parish.—New gas-condensate sand found at 8900 ft. on east flank of dome ¼ mile east of previous production. Dry test (10,823 ft.) drilled on northeast flank approximately 2 miles north of production.

Charenton, St. Mary Parish.—Deep production extended ¼ mile southward on south flank.

Deer Island, Terrebonne Parish.—Dry test (11,075 ft.) drilled on southwest flank ½ mile from production.

Delacroix Island, Plaquemines Parish.—Dry test (10,529 ft.) drilled on north flank ¼ mile north of production. Production extended ¼ mile eastward.

Delarge, Terrebonne Parish.—New oil sand found at 13,500 ft. on southwest flank extending field ½ mile southwestward. This is the deepest oil-producing well in the world.

Delta Duck Club, Plaquemines Parish.—Four new oil sands found at 9200 ft., 9800 ft., 10,200 ft. and 10,600 ft., extending the field in all directions except east. Dry test (12,010 ft.) drilled on northwest flank 3800 ft. northwest of production.

Delta Farms, Jefferson, Lafourche Parishes.—New oil sand found at 9400 ft. on northwest flank. Sixteen completions extended the field in all directions except on the south. This field was one of the most active in south Louisiana during 1944.

Dog Lake, Terrebonne Parish.—Two new oil sands found at 8900 and 9300 ft. on the west flank of the dome 2 miles west of previous production.

East Gibson, Terrebonne Parish.—Two new gas-condensate sands found at 5900 and 8400 ft. Field extended ½ mile to the east.

East Hackberry, Cameron Parish.—New oil sand found at 10,800 ft. on southeast flank extending field ½ mile southeast.

East White Lake, Vermilion Parish.—Production extended in all directions except to the west.

Egan, Acadia Parish.—New oil sand found on northeast flank at 10,770 ft. extending production approximately 1½ miles. Gas-

condensate production extended 4100 ft. on southwest flank.

Erath, Vermilion Parish.—Cycling plant now is in operation producing approximately 16,000 bbl. of liquid per day and processing approximately 200 million cubic feet of gas per day. Oil sands at 7300 and 7800 ft. were actively developed during 1944.

Freshwater Bayou, Vermilion Parish.—Production extended approximately one mile northeast of discovery well. Dry test (12,400 ft.) drilled on west flank approximately 1½ miles west of discovery well.

Garden Island Bay, Plaquemines Parish.—Production extended approximately ½ mile northward along southwest flank.

Gueydan, Vermilion Parish.—Production extended ½ mile on north flank, but limited by deep dry test (10,821 ft.). Dry test drilled on east flank (9885 ft.) and on southeast flank (9625 ft.).

Hayes, Calcasieu Parish.—Dry test (9226 ft.) drilled approximately one mile south of discovery well.

Hester, St. James Parish.—New gas-condensate sand found at 9700 ft. on north flank of dome extending production ¼ mile. Two dry tests (9329 and 10,517 ft.) drilled on northwest flank approximately one mile west of production. Production extended on southwest flank of dome.

Hope Villa, East Baton Rouge Parish.—Dry test (10,100 ft.) drilled ¼ mile northwest of discovery well.

Iowa, Calcasieu, Jefferson Davis Parishes.—Dry test (9575 ft.) drilled approximately ½ mile north of production.

Jefferson Island, Iberia Parish.—Dry test (10,402 ft.) drilled on west flank of dome approximately 3000 ft. northwest of production.

Krotz Springs, St. Landry Parish.—Production extended approximately one mile on east, north and west flanks. New gas-condensate sand found at 10,100 ft. on southwest flank. Dry test (10,874 ft.) drilled approximately 9000 ft. northeast of production.

Lake Arthur, Jefferson Davis Parish.—Production extended approximately ¾ mile on northwest flank.

Lake Chicot, St. Martin Parish.—New gas-condensate sand found at 10,300 ft. on north flank of dome. Production also extended along north flank of dome. Dry test (11,855 ft.) drilled on southeast flank 3500 ft. southeast of production.

Lake Mongulois, St. Martin Parish.—New oil sand found at 10,500 ft. on north flank of dome 1700 ft. northwest of previous production. Dry test (9766 ft.) drilled on west flank of dome 6200 ft. southwest of production.

Lakeside (Lowry), Cameron Parish.—Production extended ¾ mile to southeast flank.

LaPice, St. James Parish.—Four new oil sands found at 7000 ft., 8800 ft., 9900 ft. and 10,000 ft. extending production approximately one mile on the southwest and west flanks.

LaPlace, St. John the Baptist Parish.—Dry test (11,198 ft.) drilled on northwest flank approximately 1½ miles northwest of production.

Leeville, Lafourche Parish.—New oil sand found at 11,400 ft. on southwest flank of dome approximately 1400 ft. southwest of previous production.

Lockport, Calcasieu Parish.—New oil sand found at 7250 ft. on north flank of dome.

Neale, Beauregard Parish.—Production extended ½ mile on east, south and west flanks. During 1944, 37 completions were made in this field. One of the most active fields in south Louisiana.

North Crowley, Acadia Parish.—Production extended 3000 ft. on southwest flank. Dry test (9661 ft.) drilled on southwest flank ¼ mile southwest of production.

North Elton, Allen Parish.—Field extended ½ mile northeast production.

North Richie, Acadia Parish.—Production extended approximately ½ mile on northwest flank. Dry test (9182 ft.) drilled approximately 900 ft. north of production on northwest flank.

North Tepetate, Acadia Parish.—New oil sand found at 7800 ft. in central part of field. New gas-condensate sand found at 8000 ft. on south flank approximately one mile south of previous gas-condensate production.

Pecan Island, Vermilion Parish.—Production extended approximately one mile southeast of discovery well.

Pecan Lake, Cameron Parish.—Dry test (12,480 ft.) drilled approximately one mile northwest of discovery well. Discovery well deepened from 10,184 to 12,003 ft., but failed to produce and recompleted in original perforations.

Perkins, Calcasieu Parish.—Production extended approximately 1400 ft. to the west.

TABLE 3.—*New Discoveries in Louisiana, 1944*

	Field and Parish	Operator, Lease and Well No.	Location			Completion Date	Total Depth, Ft.	Producing Depth, Ft.	Production, Daily Rate		Choke	B.S. and W., Per Cent	Gravity, A.P.I. 60°F.	Gas-Oil Ratio, Cu. Ft. per Bbl.	Tubing Pressure, Lb. per Sq. In.	Geologic Age of Production	Remarks
			Sec.	Tp.	Rge.				Bbl.	M Cu. Ft.							
	NORTH LOUISIANA																
1	Ada, *Webster*	Carter Oil Co., N. P. Davis No. 1	33	18 N	8 W	9-30-44	7,600	5,465–5,520	21	5,210	3/8			248,000/1	1,667	Rodessa	Gas condensate
2	Benton, *Bossier*	Barnsdall Oil Co., J. T. Hanks No. 1	7	20 N	12 W	9-20-44	8,765	8,104–8,140	241	4,700	1/4		61.7	20,000/1	2,700	Cotton Valley	Gas condensate
3	Delhi, *Richland*	C. H. Murphy, Jr., J. E. Holt No. 1	21	17 N	9 E	12-9-44	3,425	3,280–3,290	505	268	16/64	0.2	41.7	530/1	625	Paluxy	Oil
4	North Holly Ridge, *Tensas*	Chicago Mill and Lbr. Co., Mutual No. 1	12	11 N	9 E	1-30-44	8,436	3,008–3,030	132	50	16/64	16	28.6	380/1	180	Wilcox	Oil
5	Spider,[a] *De Soto*	A. W. Phillips and G. C. Schoonmaker, Anthony No. A-1	9	11 N	14 W	8-20-44	5,003	4,876–4,880		125	Open				2,375	Jeter	Gas
6	Tremont, *Lincoln*	California Co., Jessie Mae Norris No. 1	15	18 N	1 W	10-26-44	9,520	9,060–9,080	66	2,500	1/8		49.4		3,850	Cotton Valley	Gas condensate
7	Trenton, *De Soto*	J. A. Johnson et al., J. J. Guy No. 1	3	11 N	13 W	8-22-44	2,736	2,732–2,736	50		1/8		44.0		600	Paluxy	Oil
	SOUTH LOUISIANA																
8	Bayou des Glaises,[a] *Iberville*	Humble Oil and Ref. Co., Wilbert's Mineral Corp. "B" No. 4	76	8 S	8 E	5-27-44	10,927	9,841–9,853	284	234	10/64	0.1	35.8	823/1	1,860	MioL	Oil
9	Bayou Penchant, *Terrebonne*	Superior Oil Co., Continental Ld. and Fur Co. No. 1	30	18 S	14 E	3-3-44	11,828	9,929–9,935	12	2,072	10/64	0	48.8	172,666/1	3,625	MioU	Gas condensate
10	China,[a] *Jefferson Davis*	Continental Oil Co., H. J. Shoesmith No. 1	1	8 S	4 W	3-27-44	10,092	9,188–9,199	32	760	7/64		57	23,401/1	3,350	MioL	Gas condensate
11	College Point, *St. James*	Humble Oil and Ref. Co., Mrs. Roana Roussel Keller et al. No. 1	31	12 S	4 E	6-28-44	10,893	10,758–10,765	324.6	11,533	5/16	0.1	48.5	35,486/1	4,990	MioL	Gas condensate
12	Crowley, *Acadia*	Phillips Petr. Co., Onezime No. 1	16	10 S	1 E	10-4-44	10,000	9,738–9,741	33	2,540	11/64	0	47.5	77,000/1	3,300	MioL	Gas condensate
13	East Moss Lake, *Calcasieu*	Continental Oil Co., Prairie Canal Co. Inc "A" No. 1	2	11 S	9 W	5-5-44	11,325	10,410–10,420	97.2	1,168	10/64	PLO	53	12,037/1	3,600	MioL	Gas condensate
14	Good Hope, *St. Charles*	Pure Oil Co., General Amer. Trans. Corp. No. 1	7	12 S	8 E	8-14-44	10,171	7,830–7,838	292.9	171	5/32	0.2	36.2	583/1	1,320	MioU	Oil
15	Gordon, *Beauregard*	Union Oil Co. of California, Edgewood L. and L. Co. No. 1	25	6 S	10 W	3-9-44	6,900	6,767–6,770	32	834	8/64	0	61	26,079/1	400	MioL	Gas condensate
16	Gum Cove, *Cameron*	Magnolia Petr. Co., R. A. Moore No. 2	13	12 S	12 W	2-9-44	10,074	9,142–9,147	54	1,336	1/4	Tr.	54.9	24,741/1	1,200	Mio	Gas condensate
17	Indian Village, *Jefferson Davis.*	Continental Oil Co., King Corporation No. 1	30	7 S	6 W	10-4-44	9,302	7,135–7,145	178.2	61		0.1	37	344/1	1,000	MioL	Oil
18	Laurel Ridge, *Iberville*	Humble Oil and Ref. Co., A. Hymel et al. No. 1	91	10 S	13 E	7-3-44	10,846	10,688–10,705	113	5,650		0	49.5	50,000/1	3,100	MioL	Gas condensate
19	North Cankton, *St. Landry*	Sun Oil Co., E. M. Boagni Estate No. B-1	48	8 S	4 E	4-17-44	10,512	9,667–9,690	470	199	9/64	0.1	36.1	423/1	1,800	MioL Hackberry	Oil
20	South Lake Charles, *Calcasieu.*	Continental Oil Co., Glen Greathouse No. 1	9	11 S	8 W	11-2-44	11,019	10,018–10,026	129.6	1,852	11/64	0.2	53.3	14,359/1		MioL	Gas condensate
21	West Tepetate, *Jefferson Davis.*	Barnsdall Oil Co., Minos Miller No. 1	38	7 S	3 W	9-30-44	10,034	8,516–8,526	793.8	748	16/64	0	34.2	942/1	1,300	MioL	Oil
22	West Bastian Bay, *Plaquemines.*	Phillips Petr. Co., Fasterling No. 3	44	20 S	28 E	3-30-44	11,135	9,164–9,166	170.4	113	7/64	0.1	34.8	665/1	1,400	MioU	Oil

[a] Rediscovery.

Pine Prairie, Evangeline Parish.—Production found on northwest and southwest flanks. Dry test (7595 ft.) drilled on southwest flank inside of production. Dry test (11,007 ft.) drilled on south flank approximately ½ mile south of production.

Plumb Bob, St. Martin Parish.—Production extended on north flank ¾ mile.

Port Barre, St. Landry Parish.—New oil sand found at 7800 ft. on south flank. Production extended southeastward along southwest flank ¾ mile. Dry test (11,751 ft.) drilled on south flank approximately 1400 ft. south of production. Production slightly extended on north flank and limited by dry test (6672 ft.).

Potash, Plaquemines Parish.—New oil sand found at 1800 ft. on southwest flank. Dry test (10,095 ft.) drilled on northwest flank of dome approximately 600 ft. north of production. Northwest flank production extended under Mississippi River.

Quarantine Bay, Plaquemines Parish.—Production extended along north and northeast flanks.

Rabbit Island, Iberia Parish.—Dry test (8894 ft.) drilled approximately one mile northeast of discovery well.

Raceland, Lafourche Parish.—Dry test (10,975 ft.) drilled approximately 4600 ft. southwest of production. Dry test (11,256 ft.) also drilled approximately 1½ miles south of production.

Reddell, Evangeline Parish.—New gas-condensate sand found at 9700 ft. on west flank extending field approximately ½ mile west. Field also extended ½ mile to the northwest and south. Dry test (12,080 ft.) drilled on north flank approximately ⅝ of a mile north of production.

Richie, Acadia Parish.—Dry test (9744 ft.) drilled on southeast flank approximately 700 ft. south of production.

Roanoke, Jefferson Davis Parish.—Production extended ½ mile on west and northwest flanks.

Rosedale, Iberville Parish.—New oil sand found at 10,100 ft. on north flank extending production approximately ½ mile northward. New gas-condensate sand found at 10,200 ft. on south flank extending production approximately 3000 ft. Field also extended approximately one mile east. Dry test (10,750 ft.) drilled on southeast flank approximately one mile from production.

St. Gabriel, Iberville Parish.—Production extended ¼ mile on west flank. Dry test (10,510 ft.) drilled on northeast flank 3400 ft. from production. Dry test (9818 ft.) drilled on west flank ¼ mile from production.

St. James, St. James Parish.—Production extended ½ mile south of discovery well. Dry test (10,890 ft.) drilled ½ mile west of discovery well.

St. Martinville, St. Martin Parish.—New gas-condensate sand found at 9700 ft. on north flank approximately 7900 ft. north of production.

Section 28, St. Martin Parish.—New oil sand found at 11,000 ft. on north flank approximately 3600 ft. east of gas-condensate production on north flank.

Shuteston, St. Landry Parish.—Production extended ¼ mile south of discovery well.

Sorrento, Ascension Parish.—Dry test (10,370 ft.) drilled approximately 2 miles west of production. Dry test (6662 ft.) drilled on northeast flank approximately ½ mile northeast of production.

South Houma, Terrebonne Parish.—Dry test (11,281 ft.) drilled on west flank approximately 1½ miles west of production. Dry test (11,035 ft.) drilled approximately 2 miles northwest of production.

South Lewisburg, Acadia Parish.—Production extended 3000 ft. east of discovery well.

Starks, Calcasieu Parish.—New oil sand found at 8000 ft. on northwest flank approximately one mile northwest of production. Subsequently offset completions were made to the east and southeast of new production. Dry tests were drilled approximately ¼ mile south, ¼ mile southwest and 1½ mile northwest (8452 ft.) of new production.

Sulphur Mines, Calcasieu Parish.—Dry test (7455 ft.) drilled on northwest flank approximately ¼ mile north of production.

Sweet Lake, Cameron Parish.—Dry test (6925 ft.) drilled on north flank approximately ¼ mile from production.

University, East Baton Rouge Parish.—Production extended approximately 2700 ft. on southwest flank, but limited by dry test (7878 ft.) approximately 1500 ft. south of most southerly extension.

Valentine, Lafourche Parish.—Dry test (7761 ft.) drilled on north flank 300 ft. north of production.

Venice, Plaquemines Parish.—Productive band on flanks of dome extended on northeast, east, southeast and southwest flanks.

Vinton, Calcasieu Parish.—One of the most active fields in south Louisiana with 29 completions for 1944. Dry tests drilled on east and west sides of deep north flank production. Salt found at 5182 ft. on northern flank inside of deep production.

West Bay, Plaquemines Parish.—New oil sand found at 10,450 ft. on southwest flank of dome. New oil sand found 10,900 ft. on west flank of dome extending production ¼ mile.

West Gueydan, Vermilion Parish.—Two new oil sands found on southeast flank at 9600 and 10,400 ft. New gas-condensate sand found on southeast flank at 9800 ft. New sands extend field approximately ½ mile to the southeast.

West Hackberry, Cameron Parish.—Top of dome extensively tested for sulphur through drilling of 14 test wells. Two additional wells were completed in the salt for brine production.

West Lake Verret, St. Martin Parish.—Producing area extended slightly on the east and southeast flanks.

West White Lake, Vermilion Parish.—New oil sand found at 10,680 ft. in well completed approximately 3000 ft. north of discovery well.

White Castle, Iberville Parish.—Dry test (10,053 ft.) drilled on southwest flank approximately 1600 ft. southwest of production. Dry test (10,103 ft.) drilled on east flank approximately 800 ft. from production.

Wildcat Wells

During the year, 127 wildcat, or exploratory wells, were drilled, as compared with 156 during 1943. In 1943 only 14.7 per cent were successful, whereas, 15 per cent were successful in 1944. The apparent value of reserves found during 1944 is difficult to evaluate. It would appear that considerably more oil reserves were found in south Louisiana during 1944 than during 1943. In north Louisiana a greater reserve apparently was found during 1943. In all, 66 wildcat wells were drilled in north Louisiana during the past year. Of this total five wells tested the Wilcox, 18 the Upper Cretaceous, 29 the Lower Cretaceous, 12 the Jurassic, one the Sparta, and one the Catahoula. In south Louisiana, 61 wildcat wells were drilled. Of this number, one was abandoned in the Pliocene, 29 in the Upper Miocene, 22 in the Lower Miocene, one in the Cockfield, six in the Wilcox and two were abandoned in cap rock.

Oil and Gas Development in Michigan during 1944

By Theron Wasson,* Member A.I.M.E.

The discovery of eight new oil fields, two of which may be of major importance, was the outstanding record in Michigan this year. These new fields have helped to support the declining production from old areas and place the total of 18,559,000 bbl. in line with the past six or seven years. Thus, it appears that Michigan is doing its part in maintaining the production of the country in the third year of the war. The new fields are in the central basin area where oil was first discovered in Michigan, thus tending to focus attention on the deeper part of the lower peninsula of the state. Through 1944 the state of Michigan has produced a total of 222,641,580 bbl. of crude oil from 100 pools, many of which are relatively small.

Among the previously discovered fields Reed City is still the outstanding producer, with Fork, Headquarters, and Adams following in the order named. The Reed City pool produced a little over 5,000,000 bbl., which was more than one third of the state's total for the year. Almost two thirds of the year's total oil production came from fields discovered in the past five years.

Maps

A map of the oil and gas fields of Michigan in 1943, published in the A.I.M.E. report for 1944,* shows the main producing areas and should be referred to if information in regard to their location is desired. The producing zones are shown in the columnar section in the same publication.* The data in Tables 1 and 2 have been carefully checked and every effort has been made to show as complete information as possible.

New Discoveries and New Developments

Eight new producing areas were discovered during 1944 which, in order of importance, are:

Deep River Field.—The discovery well in the Deep River field was drilled by Don Rayburn and others, and should be listed as a chance discovery, as, from a geological standpoint, it was not considered favorable until oil was found at a depth of 2838 ft. in a dolomitic layer in the top of the Dundee limestone. The first well was completed in January 1944, with an initial production of 2500 bbl. By the end of the year 15 wells had been completed, proving an area 2½ miles long and ½ mile wide.

Coldwater Field.—The Coldwater field was discovered in August 1944, by the Sohio Oil Co. Production is from secondary dolomite at the top of the Dundee at a depth of 3703 ft. To the end of 1944 nine wells had been drilled on 40-acre spacing.

Essexville Field.—Essexville field was discovered by United Drillers and Producers, Inc. Eight wells had been completed to the Dundee lime by the end of 1944, and prospects were good for further development during 1945.

Hilliards Field.—Hilliards field was discovered by Cook and Fortney. Production is from the Traverse lime at an average depth of 1588 feet.

Manuscript received at the office of the Institute April 3, 1945.

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* *Trans.* A.I.M.E. (1944) **155**, 387, 388.

TABLE I.—*Oil and Gas Production in Michigan*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
1	Adams, *Arenac*	1937	(1,100) 1,220	4,756,367	1,176,690		0	0	93	10	1
2	Akron-Wisner, *Tuscola*	1938	(280) 520	198,871	27,240		0	0	17	0	1
3	Austin (gas), *Mecosta*	1935		0	0	(0) 2,200	5,738.6	0	29	0	0
4	Bangor, *Van Buren*	1939	(190) 300	519,082	58,867		0	0	30	5	2
5	Bangor, (North), *Van Buren*	1942	(400) 400	249,430	97,374		0	0	24	4	4
6	Beaverton (North), *Gladwin*	1935	(290) 450	685,813	18,900		0	0	31	3	0
7	Beaverton (South), *Gladwin*	1935	(460) 520	538,958	79,420		0	0	23	0	0
8	Bentley, *Gladwin*	1937	(840) 920	914,384	94,130		0	0	47	0	0
9	Birch Run, *Saginaw*	1934	(270) 300	212,513	6,094		0	0	28	0	0
10	Bloomingdale, *Van Buren*	1938	(1,760) 3,000	5,990,761	125,284		0	0	244	0	12
11	Breedsville, *Van Buren*	1943	(200) 220	122,046	62,465		0	0	16	7	3
12	Broomfield (gas), *Isabella*	1930		0	0	(3,360) 4,260	8,523.4	511.9	63	1	0
13	Buckeye (North), *Gladwin*	1936	(1,680) 2,900	15,370,874	318,058				266	0	7
14	Buckeye (South), *Gladwin*	1936	(1,380) 2,500	3,970,672	89,478		0	0	188	0	9
15	Cedar, *Osceola*	1943	360	321,688	162,414		0	0	9	0	0
16	Clare (gas), *Clare*	1929		0	0	(0) 400	712.6	0	9	0	0
17	Clare City, *Clare*	1938	(80) 660	29,451	4,057		0	0	2	0	0
18	Clare City (gas), *Clare*	1938		0	0	600	1,388.2	116.9	7	0	0
19	Clayton, *Arenac*	1936	(1,120) 1,320	4,017,475	182,352		0	0	60	1	0
20	Clayton (gas), *Arenac*	1936		0	0	(800) 1,440	4,353.2	444.9	31	0	3
21	Coldwater, *Isabella*	1944	(360) 800	68,429	68,429		0	0	9	9	0
22	Columbia, *Van Buren*	1938	(660) 1,230	2,076,466	47,634		0	0	104	0	13
23	Cranberry Lake (gas), *Clare*	1943		0	0	4,500	835.5	832.8	33	12	0
24	Crystal, *Montcalm*	1935	(180) 2,180	7,299,156	42,688		0	0	235	0	1
25	Crystal (gas), *Montcalm*	1935		0	0	240	553.2	64.7	7	1	1
26	Deep River, *Arenac*	1944	420	735,931	735,931		0	0	15	15	0
27	Deep River (gas), *Arenac*	1941		0	0	(1,280) 1,440	899.3	343.4	9	0	0
28	Deerfield, *Monroe*	1935	(160) 260	391,153	34,893		0	0	31	0	4
29	Diamond Springs, *Allegan*	1938	(240) 560	811,406	25,142		0	0	56	1	1
30	Dorr, *Allegan*	1938	(240) 480	305,875	10,802		0	0	27	0	4
31	Edmore, *Montcalm*	1933	(150) 160	450,424	9,203		0	0	13	0	0
32	Edenville, *Midland*	1938	(280) 400	1,202,422	28,656		0	0	35	0	0
33	Essexville, *Bay*	1944	400	126,607	126,607		0	0	8	8	0
34	Evart, *Osceola*	1942	1,120	1,954,932	725,430		0	0	28	0	0
35	Evart (gas), *Osceola*	1941		0	0	4,960	1,105.8	805.9	30	9	0
36	Fillmore, *Allegan*	1943	840	251,951	240,310		0	0	39	34	1
37	Fork, *Mecosta*	1942	2,320	2,293,727	1,436,010		0	0	53	17	2

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	x	67x	0	1,224	1,109		37.0 34.0 37.8	x 0.82 1.05	Traverse Dundee Detroit River } Dev	Ls D Ls D	P P P	2,031 2,841 4,032	15 16 5	A A A	Sylvania	4,960
2	0	9	0	x	x		43.2 42.6	1.56 x	Dundee Detroit River } Dev	Ls D	P P	2,840 3,371	5 13	A A	Sylvania	4,001
3	0	0	0	512	Ab.		0	0	Stray-Mar., Mis	Sd	P	1,390	10	A	Detroit River	4,042
4	0	18	0	x	x		29.5	x	Traverse, Dev	Ls	P	1,002	2	A	Traverse	1,248
5	0	19	0	x	x		31.3	x	Traverse, Dev	Ls	P	1,015	1	A	Traverse	1,060
6	0	16	0	x	x		41.3	0.16	Dundee, Dev	Ls	P	3,880	12	A	Dundee	4,029
7	0	22	0	x	x		41.3	0.16	Dundee, Dev	Ls	P	3,880	12	A	L. Detroit River	4,977
8	0	43	0	x	x		42.1	0.42	Dundee, Dev	Ls	P	3,500	25	A	Sylvania	5,115
9	0	25	0	x	x		33.3	0.22	Berea, Mis	Sd	P	1,529	13	A	Dundee	2,760
10	0	82	0	x	x		42.0	0.62	Traverse, Dev	Ls	P	1,216 1,277	2.5 1.5	A	Detroit River	1,904
11	0	13	0	x	x		x	x	Traverse, Dev	Ls	P	1,078	1.3	A	Detroit River	1,300
12	0	0	39	540	192		0	0	Stray-Mar., Mis	Sd	P	1,300	5	A	Detroit River	4,031
13	0	155	0	580	x		39.0	0.31	Dundee, Dev	Ls	P	3,621	11	A	Detroit River	4,696
14	0	69	0	x	x		39.0	0.25	Dundee, Dev	Ls	P	3,574	11	A	Detroit River	4,330
15	0	9	0	x	x		46.0	x	Dundee, Dev	Ls	P	3,815	2	A	Detroit River	3,972
16	0	0	0	600	Ab.		0	0	Stray-Mar., Mis	Sd	P	1,408	5	A	Detroit River	4,055
17	0	2	0	x	x		30.2	0.32	Stray-Mar., Mis	Sd	P	1,283	2	A	Dundee	3,865
18	0	0	7	605	x		0	0	Stray-Mar., Mis	Sd	P	1,283	6.5	A		
19	0	45	0	x	x		34.2	0.66	Dundee, Dev	Ls	P	2,534	12	A	Sylvania	4,163
20	0	0	23	620	141		0	0	Berea, Mis	D Sd	P	1,166	12	A		
21	9	0	0	1,441	1,413		x	x	Dundee, Dev	D	P	3,703	6.9	A	Dundee	3,759
22	0	39	0	x	x		x	x	Traverse, Dev	Ls	P	1,190	2.5	A	Trenton	3,007
23	0	0	33	540	510		0	0	Stray-Mar., Mis	Sd	P	1,293	8.6	A	Sylvania	5,201
24	0	18	0	x	x		43.5	0.38	Dundee, Dev	Ls	P	3,191	4	A	Detroit River	3,520
25	0	0	5	449	171		0	0	Stray-Mar, Mis	Sd	P	1,016	4	A		
26	15	0	0	1,200	1,050		x	x	Dundee, Dev	D Ls	P	2,798	4.5	A	Sylvania	4,311
27	0	0	8	821	500		0	0	Berea, Mis	D Sd	P	1,495	11.3	A		
28	0	18	0	x	x		42.7	0.17	Trenton, Ord	D Ls	P	2,102	9	MF	St. Peter	3,088
29	0	23	0	x	x		40.0	x	Traverse, Dev	Ls	P	1,466	3.5	A	Traverse	1,571
30	0	14	0	x	x		41.4	0.44	Traverse, Dev	Ls	P	1,596	4	A	Niagaran	3,319
31	0	5	0	x	x		43.2	0.11	Traverse, Dev	Ls	P	3,108	4	A	Dundee	3,700
32	0	23	0	x	x		45.1	x	Dundee, Dev	Ls	P	3,788	8	A	Dundee	4,015
33	5x	x	0	x	x		36.3	0.35	Dundee, Dev	Ls	P	2,832	16.2	A	Sylvania	4,130
34	0	28	0	1,456	1,372		47.8	x	Dundee, Dev	Ls	P	3,757	5.7	A	Detroit River	4,457
35	0	0	18	578	462		0	0	Stray-Mar., Mis	Sd	P	1,425	9.7	A		
36	x	38x	0	x	x		39.3	x	Traverse, Dev	Ls	P	1,525	2.7	A	Sylvania-Bass Is.	2,455
37	x	51x	0	1,444	1,416		49.0	x	Dundee, Dev	D Ls	P	3,850	2.1	A	Detroit River	4,015

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
38	Fork, (gas), *Mecosta*	1943		0	0	(800) 1,120	96.3	74.8	9	7	0
39	Freeman (gas), *Clare*	1938		0	0	(1,760) 2,080	2,513.9	600.4	16	0	0
40	Goodwell, *Newago*	1943	1,240	691,757	407,871		0	0	30	12	0
41	Goodwell (gas), *Newago*	1943	--	0	0	2,080	85.7	85.7	13	13	0
42	Gratiot, *Gratiot*	1927	(0) 400	228	0		0	0	3	0	0
43	Hart, *Oceana*	1932	(0) 180	116,275	0		0	0	17	0	0
44	Headquarters, *Roscommon-Clare*	1941	(1,500) 1,600	5,846,070	1,211,892		0	0	44	1	4
45	Hilliards, *Allegan*	1944	300	54,535	54,535		0	0	15	15	0
46	Home-Edmore (gas), *Montcalm*	1938		0	0	4,160	5,594.7	870.6	31	0	3
47	Kawkawlin, *Bay*	1938	5,000	2,133,054	725,129		0	0	124	14	0
48	Leaton, *Isabella*	1929	(1,000) 2,140	3,198,149	98,812		0	0	81	0	0
49	Leaton (gas), *Isabella*	1929		0	0	(0) 480	185.6	0	12	0	0
50	Lincoln (gas), *Clare*	1938		0	0	(2,400) 2,720	4,702.0	1,075.8	15	0	0
51	Marion-Winterfield, *Miss.-Clare*	1940	(1,240) 1,400	3,429,037	377,096		0	0	42	0	4
52	Marion-Winterfield (gas), *Miss.-Clare*	1940		0	0	(9,120) 10,400	9,396.0	3,141.9	83	0	0
53	Monterey, *Allegan*	1938	(190) 300	412,797	16,242		0	0	28	0	0
54	Mt. Pleasant, *Midland-Isabella*	1928	(1,760) 8,050	22,472,612	284,657		0	0	447	0	3
55	Muskegon, *Muskegon*	1927	(250) 2,700	6,760,680	21,016		0	0	412	0	0
56	Muskrat Lake, *Van Buren*	1941	(420) 1,050	288,431	29,760		0	0	54	0	8
57	New Haven, *Gratiot*	1935		0	0	(1,720) 2,400	7,200.9	1,227.7	53	0	2
58	Norwich, *Missaukee*	1942	1,480	211,976	183,757		0	0	19	12	0
59	Overisel, *Allegan*	1938	(1,800) 2,080	2,261,590	86,178		0	0	155	0	10
60	Porter-Yost, *Midland*	1931	(6,340) 8,440	41,294,599	859,650		0	0	536	0	6
61	Prosper, *Missaukee*	1942	(480) 520	644,681	245,266		0	0	13	0	1
62	Ravenna, (gas), *Muskegon*	1936		0	0	(0) 3,840	1,433.6	0	29	0	0
63	Reed City, *Osceola*	1941	(4,880) 5,280	24,899,701	5,194,216		0	0	188	2	3
64	Reed City (gas), *Osceola*	1940		0	0	(3,520) 4,320	9,161.7	4,010.6	29	0	5
65	Richfield, *Roscommon*	1941	(480) 920	218,207	68,960		0	0	15	3	0
66	Riverside (gas), *Missaukee*	1940		0	0	(3,040) 3,200	1,733.4	794.5	17	0	1
67	Rose Lake, *Osceola*	1943	(560) 600	526,758	437,081		0	0	18	10	1
68	Saginaw, *Saginaw*	1925	(450) 1,800	1,431,486	16,870		0	0	282	0	0
69	Salem, *Allegan*	1937	(1,690) 2,500	3,126,615	78,285		0	0	206	1	26

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
38	0	0	5	610	400		0	0	Stray-Mar., Mis	Sd	P	1,499	7.2	A		
39	0	0	13	607	448		0	0	Stray-Mar., Mis	Sd	P	1,486	12	A	Detroit River	3,957
40	0	18	0	1,020	x		43.0	x	Traverse, Dev	D Ls	P	2,784	2	A	Detroit River	3,562
41	0	0	13	411	411		0	0	Stray-Mar., Mis	Sd	P	1,143	9.9	A		
42	0	0	0	x	x		x	x	Parma, Pen	Sd	P	500	10	A	Dundee	3,100
43	0	0	0	x	x		x	x	Traverse, Dev	Ls	P	1,880	4	A	Dundee	2,436
44	0	39	0	1,509	368		40.9 48.9	0.22 x	Traverse, Dev Detroit River, Dev	Ls D	P P	3,285 3,838	5 13	A A	Sylvania	6,029
45	x	15x	0	x	x		x	x	Traverse, Dev	Ls	P	1,588	1.2	A	Traverse	1,630
46	0	0	20	515	235		0	0	Stray-Mar., Mis	Sd	P	1,327	6.7	A	Dundee	3,700
47	x	123x	0	515	235		38.0 35.0 35.3	0.32 x 1.04	Berea, Mis Dundee, Dev Salina, Sil	Sd Ls D Ls	P P P	1,515 2,846 7,775	4 35.8 6	A A A	St. Peter	10,447
48	0	43	0	x	x		43.0	0.15	Dundee, Dev	Ls	P	3,634	7.5	A	Dundee	,594
49	0	0	0	520	Ab.		0	0	Stray-Mar., Mis	Sd	P	1,239	4	A		
50	0	0	13	607	444		0	0	Stray-Mar., Mis	Sd	P	1,526	10	A	Detroit River	4,285
51	0	36	0	1,510	x		44.0 38 0 41.5	0.5 x x	Traverse, Dev Dundee, Dev Detroit River, Dev	Ls D Ls D	P P P	3,140 3,743 5,014	5 3 6	A A A	L. Detroit River	5,100
52	0	0	59	554	450		0	0	Stray-Mar., Mis	Sd	P	1,392	9	A		
53	0	17	0	x	x		37.6	x	Traverse, Dev	Ls	P	1,638	3	A	Traverse	1,808
54	0	176	0	x	x		41.8	0.12	Dundee, Dev	Ls	P	3,536	14.6	A	Sylvania	4,821
55	0	25	0	x	x		37.4 37.4	0.56 x	Traverse, Dev Dundee, Dev	Ls Ls	P P	1,682 2,050	3.5 10.0	A A	St. Peter	4,754
56	0	25	0	x	x		39.2	x	Traverse, Dev	Ls	P	1,283	1.5	A	Traverse	1,332
57	0	0	43	x	x		0	0	Stray-Mar., Mis	Sd	P	915	5	A	Dundee	3,536
58	x	19x	0	x	x		x x	x x	Dundee, Dev Detroit River, Dev	Ls D	P P	3,082 4,393	5 4.2	A A	Detroit River	4,628
59	0	83	0	x	x		42.1	0.54	Traverse, Dev	Ls	P	1,471	3	A	Detroit River	1,972
60	0	317	0	x	x		40.6	0.18	Dundee, Dev	Ls	P	3,422	12	A	Sylvania	4,733
61	0	12	0	1,402	x		x	x	Dundee, Dev	D Ls	P	3,832	4	A	Dundee	3,947
62	0	0	0	720	x		0	0	Berea, Mis	D Ls	P	1,212	10	A	Dundee	2,306
63	x	183x	0	1,414	644		x x 46.3	x x 0.51	Traverse, Dev Dundee, Dev Detroit River, Dev	Ls Ls D	P P P	2,935 3,492 3,540	5 3 7	A A A	L. Detroit River	4,333
64	0	0	24	438	288		0	0	Stray-Mar., Mis	Sd	P	1,210	5	A	L. Detroit River	4,333
65	0	12	0	x	x		35.0	x	Detroit River, Dev	D	P	4,191	8	A	Sylvania	4,440
66	0	0	16	539	355		0	0	Stray-Mar., Mis	Sd	P	1,331	15.7	A	Dundee	3,945
67	0	17	0	1,170	543		37.5	x	Traverse, Dev	Ls	P	3,125	5	A	Detroit River	3,990
68	0	43	0	x	x		46.1	0.36	Berea, Mis	D Sd	P	1,820	16	A	Sylvania-Bass Is.	3,985
69	0	128	0	x	x		38.3	0.56	Traverse, Dev	Ls	P	1,587	8	A	Trenton	3,792

South Monterey field, Allegan County, and *Bloomer field*, Montcalm County, apparently are minor Traverse discoveries, which, however, in the next year or two may develop into larger producing areas.

Pinconning Field.—Pinconning field was a discovery by the Shell Oil Co. after detailed seismograph work. Dry-hole offsets make it appear that seismograph work in this area may have made it possible to discover a one-well oil field with the first test.

Bellyachers Field.—Bellyachers field was a discovery that may be well named, as it appears to be a small area of doubtful commercial value.

Development in Old Fields

The most active development during the year in the old areas was in the Fillmore field, discovered in 1943. During 1944, thirty-four additional wells were completed, which extended the producing area northwestward.

In the Adams field, 10 additional producing wells during the year extended this field northward.

Table 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
70	Salem (New), *Allegan*	1938	(830) 1,100	3,696,325	174,220		0	0	104	0	5
71	Sauble, *Lake*	1942	(160) 200	61,436	12,344		0	0	5	0	0
72	Sherman, *Isabella*	1936	(900) 1,220	4,266,151	91,100		0	0	96	0	5
73	Six Lakes (gas), *Mecosta*	1934		0	0	(7,040) 10,280	39,910.9	4,385.3	247	0	26
74	South Tallmadge, *Ottawa*	1939	(950) 1,000	410,402	50,497		0	0	62	0	1
75	Temple, *Clare*	1938	(1,750) 2,710	13,935,889	392,336		0	0	166	0	7
76	Trowbridge, *Allegan*	1941	(900) 1,280	193,733	24,067		0	0	39	1	4
77	Vernon, *Isabella*	1930	(550) 1,100	4,524,167	64,925		0	0	73	0	2
78	Vernon (gas), *Isabella*	1930		0	0	(160) 920	1,434.0	4.9	11	0	4
79	Walker, *Kent*	1938	(4,320) 5700	9,821,859	357,020		0	0	494	0	23
80	West Branch, *Ogemaw*	1933	(4,500) 5,000	5,457,191	270,860		0	0	258	0	1
81	West Hopkins, *Allegan*	1941	(370) 480	373,774	18,979		0	0	31	0	7
82	Winfield, *Montcalm*	1938	80	54,050	2,690		0	0	5	0	0
83	Winfield (gas), *Montcalm*	1938		0	0	2,660	3,111.5	510.6	16	0	0
84	Wise, *Isabella*	1938	(1,180) 1,600	2,114,875	209,317		0	0	68	6	2
85	Wise (gas), *Isabella*	1938		0	0	(640) 960	999.3	275.3	6	0	0
86	Woodville, *Newago*	1943	(280) 400	122,846	53,940		0	0	7	0	0
87	Woodville (gas), *Newago*	1943		0	0	(2,080) 2,240	178.5	178.5	13	8	1
88	Wyoming Park, *Kent*	1939	(360) 450	121,293	9,341		0	0	21	0	4
89	Zeeland (South), *Ottawa*	1942	(350) 400	181,020	61,748		0	0	15	0	3
90	Miscellaneous			1,420,467	300,845		28,974.2	871.2	321	65	10
91	Totals			222,641,580	18,526,660		140,822.0	21,228.3	7,043	307	251

The Goodwell field added 12 additional oil wells from the Traverse lime.

In the Kawkawlin field, 14 additional Dundee producers were completed during the year. This new development was largely at the southeastern end of the field.

The Rose Lake field, discovered in 1943, was extended by 10 producing Traverse wells completed in 1944.

The Norwich field was extended a mile or more to the southwest by the completion of 12 oil wells to the Dundee and one Traverse producer.

Reed City, which in previous years was under active development, had only two new producers for the year 1944.

Cranberry Lake and Goodwell gas fields were under active development during the year.

Wildcat Drilling

The number of wildcat tests increased during 1944 as compared with the previous year; 283 wildcats were drilled, which is 54 greater than the number completed in 1943. Of these, 260 were classed as dry holes, which were spread over 47 counties. As in the past year, there was great wildcat

Table 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Oil															
	Flowing	Artificial Lift	Gas	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
70	0	67	0	x	x		41.8	0.52	Traverse, Dev	Ls	P	1,621	6	A	Detroit River	1,968
71	0	4	0	x	x		35.6	x	Traverse, Dev	Ls	P	2,134	1.5	A	Sylvania	3,765
72	0	47	0	x	x		42.0	0.44	Dundee, Dev	D Ls	P	3,648	4	A	Sylvania	4,994
73	0	0	147	512	143		0	0	Stray-Mar., Mis	Sd	P	1,275	16	A	Detroit River	3,790
74	0	53	0	x	x		42.0	x	Traverse, Dev	Ls	P	1,820	7.5	A	Traverse	2,030
75	0	100	0	1,546	x		43.8	0.27	Dundee, Dev	D Ls	P	3,895	4.5	A	Sylvania	5,462
76	0	25	0	x	x		x	x	Traverse, Dev	Ls	P	1,350	2	A	Detroit River	1,645
77	0	30	0	x	x		44.1	0.23	Dundee, Dev	D Ls	P	3,741	3	A	Dundee	3,899
78	0	0	1	585	x		0	0	Stray-Mar., Mis	Sd	P	1,300	2.2	A	Dundee	3,899
79	0	98	0	792	x		40.0	0.39	Traverse, Dev	Ls	P	1,827	6	A	St. Peter	5,222
80	0	232	0	x	x		32.7 36.8	0.35 x	Traverse, Dev Dundee, Dev	Ls Ls	P P	1,880 2,622	5 20	A A	Salina	5,405
81	0	21	0	x	x		41.5	x	Traverse, Dev	Ls	P	1,587	2	A	Traverse	1,633
82	0	4	0	x	x		43.2	0.85	Detroit River	D	P	3,355	1	A	Detroit River	3,374
83	0	0	16	445	322		0	0	Stray-Mar., Mis	Sd	P	1,124	8	A	Detroit River	3,314
84	x	64x	0	x	x		45.2	0.15	Dundee, Dev	Ls	P	3,702	10.5	A	Sylvania?	5,205
85	0	0	6	574	235		0	0	Stray-Mar., Mis	Sd	P	1,249	5	A		
86	0	0	7	x	x		x	x	Traverse, Dev	Ls	P	2,822	4.5	A	Detroit River	3,534
87	0	0	13	417	417		0	0	Stray-Mar., Mis	Sd	P	1,187	14.5	A		
88	0	8	0	x	x		39.0	x	Traverse, Dev	Ls	P	1,191	6	A	Detroit River	2,255
89	0	11	0	x	x		40.4	0.52	Traverse, Dev	Ls	P	1,494	2.1	A	Detroit River	2,053
90	x	93x	43													
91	32	3,046	559													

TABLE 2.—*Summary of Drilling Operations in Michigan*

Important Wildcats Drilled in 1944

Line Number	County	Location Sec.	Location Twp.	Location Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day Oil, U. S. Bbl.	Initial Production per Day Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Remarks
1	Allegan.......	4	3 N	12 W	1,577	Pleistocene	Traverse	Chas. Cook-Del Fortney	290	0	x	Discovery well, Hilliard's field
2	Allegan.......	27	3 N	13 W	1,624		Traverse	Allan W. Winchester	28	0	x	Oil discovery in South Monterey township
3	Arenac.......	8	19 N	4 E	2,840		Dundee	Basin & Don Rayburn	2,500	0	x	Discovery well, Deep River field
4	Bay..........	7	14 N	6 E	2,881		Dundee	United Drlrs. & Prod. Inc.	114	0	x	Discovery well, Essexville field
5	Bay..........	34	15 N	4 E	7,976		Salina	Gulf Refining Co.	0	0	x	Second deep test in Kawkawlin field. Unsuccessful in Salina gas zone
6	Bay..........	2	16 N	4 E	3,012		Dundee	Shell Oil Co.	1,200 est.	0	x	Large Dundee discovery in Pinconning township
7	Chippewa.....	7	41 N	7 E	1,050		Trenton	E. R. Morris	0	0	x	Trenton test, Upper Peninsula
8	Isabella.......	33	15 N	6 W	4,994		Sylvania	Pure Oil Co.	0	0	x	Sylvania test, Sherman field
9	Isabella.......	33	16 N	6 W	3,698		Dundee	Sohio Petroleum Co.	200	0	1/64	Discovery well, Coldwater field
10	Lapeer........	21	10 N	10 E	3,315		Sylvania	Mammoth Producing Co.	0	0	x	Sylvania test
11	Lenawee......	32	8 S	5 E	3,902		Basement complex	Walter C. Eckert	0	0	x	Reached Basement complex
12	Missaukee....	16	24 N	5 W	3,143		Dundee	Sun Oil Co.	81	0	x	Traverse producer extending Norwich field
13	Missaukee....	12	24 N	5 W	4,477		L. Detroit River	Sun Oil Co.	0	5	x	Commercial gas production in L. Detroit River in Norwich field
14	Montcalm....	32	9 N	5 W	2,660		Traverse	H. L. Wadsworth	225	0	x	Large Traverse discovery in Bloomer township, Montcalm County
15	Oceana.......	7	15 N	15 W	3,400		Sylvania	Sinclair-Wyoming	0	0	x	Sylvania test
16	Ogemaw......	17	22 N	4 E	4,537		Sylvania??	Sun Oil Co.	0	0.7	x	Sylvania test discovered gas in Berea
17	St. Clair......	9	6 N	17 E	4,948		Cambrian??	Mueller Brass Co.	0	0	x	Cambrian? test
18	Tuscola.......	5	13 N	9 E	4,138		Sylvania	Gulf Refining Co.	0	0	x	Sylvania test
19	Tuscola.......	16	13 N	11 E	4,194		Sylvania	Shell Oil Co.	0	0	x	Deep test. Many showings stimulated activity in area
20	Van Buren....	13	1 S	15 W	3,007		Trenton	Harris Oil Co.	0	0	x	Trenton test, Columbia field
21	Washtenaw...	16	1 S	7 E	6,410		Basement complex	Wm. H. Colvin	0	0	x	Reached Basement complex
22	Wayne.......	16	4 S	9 E	4,050		Basement complex	Voorhees Drilling Co.	0	0	x	Reached Basement complex

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944.....................	109	81
Number of oil wells completed during 1944.....................	224	19
Number of gas wells completed during 1944.....................	60	4
Number of dry holes completed during 1944.....................	122	260

activity in the southwestern part of the state; Allegan, Ottawa, and Van Buren Counties were particularly active. In the central Michigan basin, counties having the greatest number of exploratory tests were Mecosta, Arenac, Isabella, Osceola, Montcalm, and Newaygo. The most important result of these wildcat activities was the development of the Deep River field in Arenac County, the Coldwater field in Isabella County, and the Essexville field in Bay County. Tests into the Basement rocks in the southeastern part of the state that were under way at the end of 1943 were finished as dry holes in the Cambrian or pre-Cambrian in St. Clair, Lenawee, Washtenaw, and Wayne Counties. A test drilled by the Sinclair-Wyoming Oil Co. in Oceana County was drilled to a total depth of 3400 ft. and penetrated 90 ft. of Sylvania sandstone, which showed traces of oil and gas. The Gulf Refining Company's second deep test in the Kawkawlin field, drilled to 7976 ft. in Salina, was the deepest hole of the year.

Exploration

Two major companies continued seismograph exploration in Huron, Tuscola, and Sanilac Counties of the Thumb area. Core testing for structural markers beneath the glacial drift was done in 29 counties of the state and 197 core tests were reported as completed during the year. This was a reduction of nearly one half over the number of tests drilled in 1943. Coldwater field, of Isabella County, was discovered as a result of core drilling done in 1943. The Pinconning field was discovered by the Shell Oil Co. as a result of detailed seismograph work. Acreage held under lease as a result of various types of exploration showed an increase of nearly 500,000 acres from 2,900,000 acres at the end of 1943 to 3,280,000 acres at the end of 1944.

Proration

All flush fields were produced under State proration throughout the year with daily allowables in barrels per well. These are listed in Table 3, in which the first figure in each column applies to 20-acre units and the second figure in each column to 40-acre units.

Table 3.—*Daily Allowables*
Barrels per Well

Field	Jan. 1	June 1	Sept. 16	Dec. 24
Adams	150–262	150–262	125	125
Headquarters	125–218	125–218	125–218	125–218
Evart	86–150	86–150	86–150	86–150
Fork	86–150	125	125	125
Goodwell	150	150	Dropped	
Prosper	86–150	86–150	Dropped	
Reed City	100–175	100–175	100–175	100–175
Rose Lake	150–262	150	150	150
Deep River			300	200

Prices

Prices have remained essentially unchanged with Midland Grade at $1.44 and Sherman Grade at $1.39. Goodwell oil continued to bring $1.48 and Headquarters oil was boosted from $1.39 to $1.48. A rate of $1.44 was established on crude from the Fork field and $1.27 on crude from the Deep River field.

Acknowledgments

Mr. Carl C. Addison, Mr. D. C. Shackelford, and Mr. C. K. Clark, of The Pure Oil Company at Saginaw, Michigan, assisted in the preparation of this report. As in the past, the State Geological Survey of Michigan has furnished information on oil and gas production.

Oil and Gas in Mississippi during 1944

By H. M. Morse*

This report on oil and gas development in Mississippi covers the period from Jan. 1, 1944, to Dec. 31, 1944:

Salt Domes

During the year six salt domes were drilled for sulphur, but no commercial sulphur deposits were found. One salt dome, the Bruinsburg, in Claiborne County, has produced gas at 935 to 940 ft. in Moody's Branch marl. The Stringer salt dome in Smith County and the Ruth salt dome in Lincoln County both had a slight showing of heavy oil. Other salt domes have been dry. In addition to the Bruinsburg dome, the Allen salt dome, in Copiah County, and the Richton salt dome, in Perry County, were discovered in 1944; also the Sumrall dome, in Covington County.

New Oil Fields

Baxterville Oil Field.—The Baxterville oil field was discovered by the Gulf Refining Co. in sec. 7, T. 1 N., R. 16 W., Lamar County. At the end of the year this field had one oil well, with two active operations. Production for 1944 was 1047 bbl. of oil.

Gwinville Field.—Gwinville field was discovered by S. W. Richardson, in sec. 24, T. 9 N., R. 19 W., Jefferson Davis County. This discovery well was a gas-distillate well, the oil being crystal clear. At the end of 1944 there were two gas wells and one oil well in the field. The oil well is approximately 2½-miles from the gas-distillate wells. Gas production was 55,801 M cu. ft. and the distillate production was 2644 barrels.

Heidelberg Oil Field.—The Gulf Refining Co. discovered the Heidelberg field in sec. 30, T. 1 N., R. 13 E., Jasper County, in January 1944. This field has by far exceeded the other 1943 and 1944 discoveries, having approximately 56 oil wells, 7 dry holes, and 10 active wells at the end of the year. Production to Jan. 1, 1945 was 1,441,192 bbl. of oil.

Mallalieu Oil Field.—The California Company discovered the Mallalieu oil field in sec. 10, T. 7 N., R. 8 E., Lincoln County. At the end of the year there was one well in the field with three active operations. Production was 32,303 bbl. of oil.

Old Oil Fields

Brookhaven Oil Field, in Lincoln County, has one oil well, which produced 2590 bbl. of oil during 1944.

Cary Oil Field, Sharkey County, has only one producing well, which produced 11,818 bbl. of oil during the year.

In *Cranfield Oil Field*, Adams County, 11 oil wells and two gas-distillate wells were drilled in 1944 and there were five active wells on Dec. 31, 1944. The total production for the year was 525,422 bbl. of oil. The gravity of the oil is 40° to 54.9°.

In *Eucutta Oil Field*, Wayne County, 34 oil wells were completed during 1944. There were five dry holes and six active wells at the end of the year. The field produced 454,332 bbl. of oil, and the average gravity is 25°.

Flora Oil Field, Madison County, pro-

Manuscript received at the office of the Institute April 4, 1945.

* Supervisor State Oil and Gas Board, Jackson, Mississippi.

duced 5276 bbl. of oil during the year. No new wells were added.

Tinsley Oil Field, Yazoo County, has a total of 313 wells and produced 11,802,564 bbl. of oil. This figure shows a steady decline in production over the previous year. No new wells were drilled, and no new discoveries were made.

In *Vaughan-Pickens Oil Field,* Madison and Yazoo Counties, six oil wells were drilled and there was one active well at the end of the year. The field produced 2,141,751 bbl. of oil in 1944.

Wildcats

During the year, 65 dry-hole wildcats were drilled in the state, and 35 were

TABLE 1.—*Oil and Gas Production in Mississippi*

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	1944 Completed	1944 Abandoned
1	Baxterville, *Lamar*	1944	40	1,047	1,047				1	1	0
2	Brookhaven, *Lincoln*	1943	40	19,301	2,590				1	0	0
3	Cary, *Sharkey*	1941	160	42,302	11,818				5	0	1
4	Cranfield, *Adams*	1943	480	538,313	525,422				13	12	0
5	Eucutta, *Wayne*	1943	1,360	455,995	454,332				35	34	1
6	Flora, *Madison*	1943	80	9,990	5,276				3	1	2
7	Gwinville,[1] *Jeff Davis*	1944	80	2,644	2,644		55.8	55.8	2	2	0
8	Heidelberg, *Jasper*	1944	2,200	1,441,192	1,441,192				56	56	0
9	Mallalieu, *Lincoln*	1944	40	32,303	32,303				1	1	0
10	Tinsley, *Yazoo*	1939	9,840	76,848,513	11,802,564				346	0	16
11	Vaughan-Pickens, *Yazoo, Madison*	1940	1,640	4,534,234	2,141,751				42	8	0
12	Bruinsburg Dome, *Claiborne*	1944				40	9.5	9.5	1	1	0
13	Jackson, *Rankin, Hinds*	1930				7,500	115.623	852	218	0	1

Line Number	Wells Producing[g] Dec. 1944: Oil Flowing	Oil Artificial Lift	Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	1	0		14.7–15.8		Tuscaloosa	Sandy S	8,690		L. Tuscaloosa	9,080
2	0	1		27		Mar. Tusc., M. sand	Sandy S	10,288		L. Cretaceous	12,229
3	1	0		24		Selma chalk	C	3,270		Cretaceous	3,775
4	13	0		40–54.9		Wilcox and Tusc., Eoc	Sandy S	5,888		M. Tuscaloosa	10,383
5	3	31		18.8–25		Tusc., M. sand	Sandy S	6,660		L. Tuscaloosa	7,100
6	0	1		26		Selma chalk	C	4,360		Chalk	4,367
7				54.8		Tusc., Cre	Sandy S	9,224		Tuscaloosa	9,433
8	24	32		19.1–26.7		Eutaw, Cre	Sandy S	4,900	AF	Tuscaloosa	6,578
9	1	0		38		Tuscaloosa	Sandy S	10,520		L. Cretaceous	10,642
10	0	313		28–49.6		Selma C., Eut. and Tusc.	C. & Sd	4,378		Tuscaloosa	6,540
11	4	37		39.9		Eutaw, Cre	Sandy S	4,830		Tuscaloosa	5,658
12			1			Moody's Branch	Sd Sh S	935	Ds	Salt	2,324
13			18			Selma, Cre	Gas C	2,420	D	L. Cretaceous	5,529

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Distillate Field.

TABLE 2.—*Summary of Drilling Operations in Mississippi*

Important Wildcats Drilled in 1944

	County	Location Sec.	Location Twp.	Location Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
1	Claiborne	1 & 2	11 N	1 W	2,324		Salt
2	Copiah	2	10 N	5 E	10,218		L. Cretaceous
3	Copiah	16	11 N	5 E	10,502		L. Cretaceous
4	Copiah	8	9 N	7 E	10,226		L. Cretaceous
5	Forrest	19	1 N	12 W	9,872		L. Tuscaloosa
6	Forrest	20	1 S	12 W	8,551		L. Tuscaloosa
7	Jasper	30	1 N	13 E	6,578		Tuscaloosa
8	Jefferson Davis	24	9 N	19 W	9,967	Recent	L. Tuscaloosa
9	Jefferson Davis	31	6 N	18 W	11,638		L. Cretaceous
10	Jefferson Davis	34	9 N	18 W	9,433		L. Tuscaloosa
11	Jones	16	9 N	10 W	7,784		Eutaw
12	Jones	25	8 N	10 W	7,815		Tuscaloosa
13	Lamar	7	1 N	16 W	9,080		L. Tuscaloosa
14	Lincoln	10	6 N	8 E	10,642		L. Cretaceous
15	Madison	19	10 N	4 E	5,169		Eutaw
16	Madison	20	11 N	4 E	5,176		Eutaw
17	Rankin	13	7 N	4 E	12,005		L. Cretaceous

Important Wildcats Drilled in 1944

	Drilled by	Initial Production per Day Oil, U. S. Bbl.	Initial Production per Day Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. Per Sq. In. Casing	Pressure, Lb. Per Sq. In. Tubing	Remarks
1	Sun Oil Co.		14,000	14/64, 18/64, 24/64	406	406	Discovery, Bruinsburg Dome
2	Amerada Petr. Corp.						Dry hole
3	Carter Oil Co.						Dry hole
4	J. B. White & Big West Drill. Co.						Dry hole
5	Humble Oil & Ref. Co.						Dry hole
6	Morgan & Hager						Dry hole
7	Gulf Refining Co.	408		3/8			Heidelberg discovery
8	S. W. Richardson		5,000,000	1/8	3,000	2,900	Gwinville discovery
9	Sinclair Wyoming Oil Co.						Dry hole
10	Gulf Refining Co.	400	14,000	1/8 to 1/4	2,850	2,750	Extension of Gwinville
11	Gulf Refining Co.						Dry hole
12	Sinclair Wyoming Oil Co.						Dry hole
13	Gulf Refining Co.	500	238:1	5/32		1,200	Baxterville discovery
14	California Co.	374		1/4		3,200	Mallalieu discovery
15	Vaughey & Vaughey						Dry hole
16	Carter Oil Co.						Dry hole
17	Phillips Petroleum Co.						Dry hole

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944	35	31
Number of oil wells completed during 1944	112	
Number of gas wells completed during 1944	5	
Number of dry holes completed during 1944	18	65

active on Dec. 31, 1944. These wildcats were drilled in 42 different counties.

YEAR OF 1945

This year should discover several new fields, and a great many oil and gas-distillate wells should be added to the present expanding fields. The geophysical activities of 1942 and 1943 should pay off in a number of new discoveries for the year of 1945. Several deep test wells will be drilled in the Tinsley oil field to ascertain the production possibilities of the Lower Tuscaloosa, and these wells will also penetrate the Lower Cretaceous. These drillings will be a combined effort of several of the producers in the Tinsley field.

Development of Oil and Gas in Missouri in 1944

By Frank C. Greene*

Drilling in Missouri in 1944 was nearly treble the rate of 1943 because of continued development of the Tarkio pool in Atchison County and the preparation of a pool in Jackson County for a water-injection project.

The pipe line from the Prairie Point gas pool in Platte County was in operation throughout the year of 1944, but several of the shallow oil pools in Cass and Jackson Counties were off production during much of 1944 because of a shortage of help.

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* Geologist, Missouri Geological Survey, Rolla, Missouri.

Table 1 gives a summary of activities by counties. The total footage drilled was 41,475 ft., of which 21,187 ft. was by rotary tools and 20,268 ft. by cable tools.

Table 1.—*Wells Drilled for Oil and Gas and Water Injection in Missouri in* 1944

County	Number of Oil Wells	Number of Gas Wells	Dry	Water-injection Wells
Atchison	8		5	
Caldwell			1	
Holt			2	
Jackson	17	3	9	10
Platte		2	4	
Totals	25	5	21	10

Petroleum Development in Nebraska in 1944

By E. C. Reed*

Drilling activity in Nebraska continued to decline during 1944. Nine tests for oil and gas were completed during the year and four wells were drilling at the close of the year. Four wells were drilled in Richardson County, three in Hitchcock County and single wells were drilled or drilling in Butler, Gage, Holt, Nemaha and Scottsbluff Counties. Only one of the completions resulted in commercial production, the others being abandoned as dry holes.

A number of stratigraphic test holes were drilled in the state by the Stanolind Oil and Gas Co. and the Sinclair-Prairie Oil Co., in Johnson, Otoe, Chase, Dundy and Garden Counties.

No new fields were discovered during 1944 but the limits of the Barada field, Richardson County, was extended a short distance southward.

Oil production continued to drop and about two thirds as much oil was produced in 1944 as in 1943.

Manuscript received at the office of the Institute May 10, 1945.

* Nebraska Geological Survey, Lincoln, Nebraska.

TABLE I.—*Oil and Gas Production in Nebraska*

Line Number	Field, County[a]	Year of Discovery	Oil Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944			Character of Oil[i]	Producing Formation					Deepest Zone Tested[p] to End of 1944	
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Completed to End of 1944	1944		Oil		Gas	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Name	Depth of Hole, Ft.
				To End of 1944	During 1944		Completed	Abandoned	Flowing	Artificial Lift									
1	Barada, *Richardson*	1941	500	729,600	115,000	16	1	1		13		29.6	Hunton-Devonian	D	Cav	2,403	78	Viola	3,215
2	Dawson, *Richardson*	1940	440	107,000	39,000	13	0	3		10		21.7	Hunton-Devonian	D	Cav	2,192	29	Pre-Cambrian	3,424
													Viola-Ordovician			2,897	4		
3	Falls City, *Richardson*	1939	1,080	3,632,000	285,006	57	0	6		47		31.5	Hunton-Devonian	D	Cav	2,250	23	Arbuckle	3,372
4	Shubert, *Richardson*	1940	400	117,000	1,000	10	0	8		2		31.0	Hunton-Devonian	D	Cav	2,495	23	Hunton	2,638
5	Total		2,420	4,585,600	440,006	96		18		72									

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 2.—*Summary of Drilling Operations in Nebraska*

Important Wildcats Drilled in 1944

	County	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day	Remarks
		Sec.	Twp.	Rge.					Oil, U. S. Bbl.	
1	Butler......	SE-NW 29	16 N	2 E	2,489	Pleistocene on Cretaceous	Pre-Cam	Bellwood Syndicate		Dry and abandoned
2	Gage.......	NW-SW 16	3 N	5 E		Pleistocene on Cretaceous		Ellis Oil Co.		Drilling
3	Hitchcock..	SW-SW-SE 35	2 N	33 W	4,704	Pleistocene on Tertiary	Pre-Cam	Texas Co.		Dry and abandoned
4	Hitchcock..	SW-NW-NW 22	2 N	35 W	4,663	Pleistocene on Tertiary	Pre-Cam	Texas Co.		Dry and abandoned
5	Hitchcock..	SE-SE-SW 29	4 N	35 W	5,015½	Pleistocene on Tertiary	Pre-Cam	Texas Co.		Dry and abandoned
6	Holt.......	C-N½ 32	33 N	11 W		Alluvium on Cretaceous		Winn & Shaner		Drilling
7	Nemaha	NW-NW 23	6 N	13 E	1,970	Alluvium on Permian	Dev-Hunton	Dan Short et al.		Dry and abandoned
8	Otoe.......	NW-SE 21	7 N	12 E	1,158	Pleistocene on Pennsylvanian	Pre-Cam	Woodward Oil Co.		Dry and abandoned
9	Richardson.	SE-SE-SE 34	3 N	15 E	2,570	Pleistocene on Pennsylvanian	Dev-Hunton	Peters & Bates		Dry and abandoned
10	Richardson.	SE-SE-NE 13	3 N	16 E	2,644	Pleistocene on Pennsylvanian	Dev-Hunton	Lee Bates et al.		Dry and abandoned
11	Richardson.	NE-NE-NW 1	2 N	16 E	2,450	Pleistocene on Pennsylvanian	Dev-Hunton	Monebia Dev. Co.	50 Est.	Producer, Barada field
12	Richardson.	N½-NW 36	3 N	16 E	3,215	Pleistocene on Pennsylvanian	Ord-Viola	Skelly Oil Co.		Old Producer deepened. Dry and abandoned
13	Scotts Bluff	NW-SW 6	20 N	54 W		Tertiary		Fuerst Oil Dev. Co.		Drilling

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944	0	3
Number of oil wells completed during 1944	1	0
Number of gas wells completed during 1944	0	0
Number of dry holes completed during 1944	1	8

Oil and Gas Development in New Mexico in 1944

By John M. Kelly,* Member A.I.M.E.

New Mexico produced 39,475,388 bbl. of oil in 1944, the greatest amount in one year in the oil history of the state. This production was 593,046 bbl. or 1.25 per cent more than in 1943. New Mexico retained its position as the seventh largest oil-producing state.

The maximum per well allowable on Jan. 1, 1944 was 48 bbl. daily and at the end of the year it was 45 bbl. daily. Allocations as set by the New Mexico Oil Conservation Commission closely followed the recommendations made by the Petroleum Administrator for War. The average daily pipe-line runs were within 4 per cent of the allocation. Production by counties was as follows; Lea County, 33,509,548 bbl.; Eddy County, 5,504,498; Northwestern New Mexico 461, 342.

Drilling activity for New Mexico in 1944 was well above that of 1943, with 362 completions. Of these, 283 were oil wells, 12 gas wells and 67 dry holes. The ratio of dry holes to producers, about 1 to 4, was an improvement over 1943.

Wildcat drilling during 1944 was responsible for the discovery of six new fields and the extension of two present producing areas.

Drilling records were established in New Mexico during 1944 with the deepest producer ever completed, the Humble Leonard Oil Company's No. 1 at 11,969 ft., in the Ellenburger section of Ordovician age near Jal, Lea County.

Southwestern New Mexico

Lea County

The discoveries in Lea County during 1944 were as follows:

West Lovington field, where Fred Turner, Jr. drilled his No. 1 State B in C SE SW sec. 4-17-36 and completed it for 122 bbl. of oil in 8½ hr., in the San Andreas section of Permian age.

The Tonto field, where the Texas Company completed its No. 1 Baskin at a total depth of 3586 ft. in Seven Rivers lime of Permian age, with an initial production of 254 bbl. of oil in 21 hours.

The Drinkard area, where the Gulf Oil Corporation's Drinkard No. 1 flowed 782 bbl. of oil in 14 hr. from the Yeso section of lower Permian age, thus opening the first lower Permian production in the state. The total depth of this discovery was 6508 ft. and oil was 38.8° A.P.I. gravity.

The Dublin area, where the Humble Oil and Refining Co. established a drilling depth record of 11,969 ft. drilling and completing its No. 1 Leonard Oil Co. well in the Ellenburger lime of Ordovician age. This well flowed 221 bbl. of oil per day, of 48.9° A.P.I. gravity oil. It is in sec. 12-26-37.

The new pay horizon discovery of the Continental Oil Co. in the Skaggs area, where the company completed its Skaggs B-23 No. 2 in sec. 23-20-37 for 236 bbl. of oil in 21 hr. from the Wolfcamp section of lower Permian age, at a total depth of 7725 ft. This well was drilled to granite at 10,465 ft. and plugged back to the Wolfcamp for a new pay zone completion.

Manuscript received at the office of the Institute May 22, 1945.

* Production Superintendent, G. P. Livermore, Inc. Lubbock, Texas.

TABLE 1.—*Oil and Gas Production in New Mexico*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil, Flowing	Wells Producing[g] Dec. 1944: Oil, Artificial Lift	Wells Producing[g] Dec. 1944: Gas
1	Anderson, *Eddy*	1940	1,320	568,444	52,746	0	349	40*x*	33	1	0	18	5	0
2	Arrowhead, *Lea*	1938	8,360	7,915,996	1,948,228	40	12,409	4,039	125	12	0	123	1	1
3	Artesia, *Eddy*	1923	5,610	5,138,170	159,116	120	16,714	50*x*	222*x*	10	0	6	171	3
4	Aztec-Bloomfield, *San Juan*	1924	170	41,836	0	20	142	10	34	0	0	0	13	2
5	Barber, *Eddy*	1936	920	657,557	113,213	80	*x*	*x*	24	1	0	0	20	2
6	Barker Creek Dome, *San Juan*	1942	0	0	0	1,280	3,199	1,422	8	4	0	0	0	8
7	Benson, *Eddy*	1943	160	80,616	67,033	0	*x*	*x*	4	1	0	0	4	0
8	Blanco, *San Juan*	1929	40	1,463	0	40	375	0	1	0	0	1	0	1
9	Caprock, *Lea and Chaves*	1940	280	15,923	13,593	0	*x*	*x*	7	6	0	1	7	0
10	Comanche, *Chaves*	1936	120	11,250	0	0	0	0	3	0	0	0	3	0
11	Cooper, *Lea*	1929	4,680	15,244,911	591,961	360	120,214	3,106	114	0	0	23	54	9
12	Corbin, *Lea*	1938	80	58,604	10,531	40	0	0	3	0	0	0	2	1
13	Dayton, *Eddy*	1940	600	93,030	19,005	40	39	0	17	4	0	11	0	1
14	Drinkard, *Lea*	1944	40	0*x*	0*x*	0	*x*	*x*	1	1	0	1	0	0
15	Dublin, *Lea*	1944	40	0*x*	0*x*	0	*x*	*x*	1	1	0	1	0	0
16	East Lusk, *Lea*	1942	240	128,425	31,873	0	*x*	0	6	0	0	1	4	0
17	East Maljamar, *Lea*	1942	1,040	308,504	245,464	0	159	77	26	10	0	18	6	0
18	Eaves, *Lea*	1929	1,200	3,143,832	378,769	80	14,100	1,120	30	3	0	14	14	2
19	Eunice, *Lea*	1928	39,440	71,435,900	6,393,293	40	291,797	26,803	505	0	0	385	99	1
20	Fenton, *Eddy*	1943	40	835	290	0	*x*	*x*	1	0	0	0	1	0
21	Fulcher Basin, *San Juan*	1934	0	0	0	1,420	4,555	1,597	13	3	0	0	0	13
22	Getty, *Eddy*	1928	360	852,628	78,960	40	*x*	*x*	13	2	0	0	8	1
23	Grayburg-Jackson, *Eddy*	1936	11,240	15,495,196	1,979,331	80	23,220	3,000*x*	290	48	0	217	55	2
24	Halfway, *Lea*	1939	400	408,280	70,049	0	0	0	10	0	0	0	6	0
25	Hardy, *Lea*	1935	6,080	5,265,348	339,471	0	259,112	1,872	134	5	0	79	48	0
26	High Lonesome, *Eddy*	1939	400	28,264	2,610	40	321	5*x*	10	0	0	0	2	1
27	Hobbs, *Lea*	1928	10,280	108,825,939	4,100,545	120	221,816	6,605	272	2	0	201	52	3
28	Hogback, *San Juan*	1922	160	2,272,113	65,886	0	*x*	*x*	7	0	0	7	0	0
29	Hospah, *McKinley*	1927	700	1,300,388	320,231	0	*x*	*x*	38	8	0	0	38	0
30	Jal, *Lea*	1927	1,960	6,301,193	135,783	360	47,200	2,946		1		8	10	9
31	Kutz Canyon, *San Juan*	1927	0	0	0	2,520	17,180	1,448	17	0	0	0	0	17
32	Langlie, *Lea*	1927	6,280	9,370,289	731,704	680	117,931	16,706	152	1	0	107	12	14
33	Leo, *Eddy*	1939	320	107,337	11,876	0	35	*x*	8	1	0	1	6	0
34	Leonard, *Eddy*	1929	2,320	1,743,945	459,924	320	1,733	150*x*	66	13	0	43	9	8
35	Loco Hills, *Eddy*	1939	9,120	8,938,402	1,117,252	80	11,294	1,300*x*	226	14	0	157	36	0
36	Lynch, *Lea*	1929	440	7,194,394	118,853	0	*x*	0	16	0	0	0	9	0
37	Lynn, *Lea*	1929	2,040	2,577,979	347,628	200	17,727	2,832	53	2	1	20	18	3
38	Maljamar, *Lea*	1926	8,920	9,310,283	1,830,307	40	20,941	1,583	222	14	0	166	23	1
39	Mattix, *Lea*	1936	8,360	8,479,734	673,329	360	66,239	11,174	189	0	0	120	45	8
40	McMillan, *Eddy*	1938	80	484	0	0	0	0	2	0	0	0	1	0
41	Monument, *Lea*	1934	37,040	66,787,684	7,515,807	0	167,658	14,484	514	0	0	466	29	0
42	North Lynch, *Lea*	1929	80	174,474	5,948	0	47	3	2	0	0	0	2	0
43	North Maljamar, *Lea*	1939	40	2,876	0	0	0	0	1	0	0	0	1	0
44	Penrose, *Lea*	1935	13,500	8,899,211	504,084	0	50,387	4,206	195	1	0	116	75	0
45	Rattlesnake, *San Juan*	1924	680	4,710,466	53,079	10	*x*	*x*	84	4	0	0	39	1
46	Red Lakes, *Eddy*	1924	3,880	749,906	69,647	640	882	75*x*	100	12	*x*	8	52	16
47	Red Mountain, *McKinley*	1933	40	3,370*x*	0*x*	0	0	0	9	2	1	0	7	0
48	Rhodes, *Lea*	1928	2,700	999,614	297,093	480	61,902	5,121	54	10	0	30	2	12
49	Robinson, *Eddy*	1926	560	481,157	24,049	0	195	12*x*	14	0	0	0	11	0
50	Russell, *Eddy*	1941	450	80,390	45,622	80	*x*	*x*	16	5	0	3	8	0
51	Salt Lake, *Lea*	1941	320	196,765	50,642	0	0	0	8	0	0	0	8	0
52	San Simon, *Lea*	1943	80	19,183	16,947	0	2	2	2	1	0	0	2	0
53	Shugart, *Eddy*	1938	1,480	981,583	142,623	0	472	80*x*	37	1	0	17	13	0
54	Skaggs, *Lea*	1936	160	190,158	21,884	0	390	48	4	1	0	3	1	0
55	Skelly, *Lea*	1936	6,200	3,740,632	262,762	480	18,961	2,572	101	1	0	24	61	3
56	South Eunice, *Lea*	1930	4,440	7,038,480	787,964	120	29,488	5,515	112	1	0	64	5	3
57	South Lovington, *Lea*	1938	4,400	2,900,268	656,962	80	2,615	772	49	3	0	28	15	2
58	South Maljamar, *Lea*	1939	320	170,613	43,639	0	68	17	8	1	0	4	3	0

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
1	x	x	0	36.0	0.9	Grayburg, Per	S	x	2,527	x	A	San Andres, Per	3,634
2	1,460	x	0	36.0	1.0	Grayburg, Per	D	Cav	3,720	80	A	San Andres, Per	3,960
3	x	x	0	35.0	1.04	Yates, Queen, Grayburg, Per	S & L	x	460 1,875	25	A	San Andres, Per	4,035
4	x	x	0	55.0	0.10	Farmington Sand, CreU	S	x	750	25	S	Lewis Shale, CreU	2,665
5	550	x	0	20.5	0.9	Yates, Per	L	Cav	1,480	x	A	Seven Rivers, Per	1,953
6	x	x	0			Dakota Sand, CreU	S	x	2,350	50	D	Hermosa, Penn	7,630
7	x	x	0	26.0	0.9	Yates, Per	L	x	1,760	50	A	Queen, Per	2,988
8	1,200	x	0	54.0	0.13	Mesa Verde, Pictured Cliffs, CreU	S	x	4,250	x	H	Mesa Verde, CreU	4,550
9	x	x	0	36.0	1.0	Queen, Per	S	x	3,025	27	A	San Andres, Per	4,085
10	x	x	0	28.5	0.9	San Andres, Per	L	x	x	x	ML	San Andres, Per	1,400
11	1,398	x	0	29.9	1.5	Seven Rivers, Per	D	Cav	3,542	55	A	San Andres, Per	5,095
12	x	x	0	30.5	1.0	Queen, Per	S	x	4,258	45	A	Grayburg, Per	5,118
13	x	x	0	37.0	0.9	Grayburg, San Andres, Per	LS	Fis	1,096	x	A	San Andres, Per	2,545
14	x	x	0	38.8	0.1	Yeso, Per	LS	x	6,375	125	A	Yeso, Per	6,508
15	x	x	0	47.3	0.1	Ellenburger, Ord	LS	Cav	11,870	135	A	Ellenburger, Ord	11,969
16	x	x	0	24.1	0.9	Yates, Per	L	x	2,702	25	A	Seven Rivers, Per	2,820
17	x	x	0	38.5	0.9	Grayburg, San Andres, Per	LS	x	4,187	75	A	Yeso(?) Per	8,610
18	x	x	0	28.5	1.0	Yates, Seven Rivers, Per	S & L	x	3,170	x	A	Seven Rivers, Per	3,542
19	1,400	831	0	33.8	1.28	Grayburg, Per	D	Cav	3,800	75	A	San Andres, Per	4,404
20	x	x	0	43.0	0.6	Delaware, Per	S	x	2,638	10	A	Delaware, Per	3,525
21	576	x	0			Pictured Cliffs, CreU	S	x	1,800	160	H	Pictured Cliffs, CreU	2,136
22	x	x	0	24.0	0.9	Yates, Per	LS	x	1,361	20	A	Bone Springs, Per	6,683
23	x	x	P	35.5	0.9	Queen, Grayburg, San Andres, Per	S & L	x	3,586	45	A	San Andres, Per	4,383
24	x	x	0	28.6	0.9	Yates, Per	LS	x	2,590	25	A	Queen, Per	4,005
25	1,400	x	0	35.0	0.9	Grayburg, Per	D	Cav	3,710	53	A	San Andres, Per	3,872
26	x	x	0	34.9	1.56	Queen, Grayburg, Per	LS	x	2,610	40	A	San Andres, Per	3,163
27	1,550	1,162	0	34.5	1.0	San Andres, Per	D	Cav	3,950	124	A	San Andres, Per	4,500
28	560	560	0	60.0	0.1	Dakota Sand, CreU	S	x	705	9	D	McElmo, CreU	1,225
29	x	x	0	29.0	0.15	Hospah Sand, CreU	LS	x	1,639	11	DF	Dakota, CreU	3,282
30	x	x	0	36.0	1.0	Seven Rivers, Per	LS	x	3,303	31	A	San Andres, Per	4,125
31	565	350	0			Pictured Cliffs, CreU	S	x	1,840	60	H	Mesa Verde, CreU	4,400
32	1,450	x	RP	38.0	0.9	Seven Rivers, Per	S	x	3,350	x	A	Pre-Cam, Granite	9,594
33	x	x	0	35.8	0.9	Grayburg, Per	S	x	3,170	x	ML	San Andres, Per	3,857
34	x	x	0	36.0	0.9	Grayburg, San Andres, Per	S	x	2,808	50	A	San Andres, Per	3,591
35	950	x	PM	36.5	0.9	Grayburg, Per	S	x	2,620	40	A	San Andres, Per	3,453
36	x	x	0	30	1.0	Yates, Seven Rivers, Per	D	Cav	3,760	17	A	Queen, Per	4,046
37	1,365	x	0	29.0	1.0	Seven Rivers, Per	D	Cav	3,576	x	A	San Andres, Per	5,095
38	x	x	RP	38.0	0.9	Queen, Grayburg, San Andres, Per	L & S	x	3,965	x	A	San Andres, Per	5,150
39	1,400	x	0	37.3	1.0	Yates, Seven Rivers, Per	S	x	3,500	45	A	San Andres, Per	4,200
40	x	x	0	29.0	1.0	Queen, Per	S	x	1,200	x	A	San Andres, Per	3,305
41	1,427	1,207	0	34.1	1.2	Grayburg, San Andres, Per	D	Cav	3,829	29	A	San Andres, Per	4,534
42	x	x	0	30.0	1.0	Yates, Seven Rivers, Per	D	Cav	3,760	17	A	Grayburg, Per	4,769
43	x	x	0	33.1	1.0	Grayburg, Per	D	x	3,875	35	A	San Andres, Per	4,097
44	x	x	0	35.2	1.0	Grayburg, Per	S	x	3,550	90	A	San Andres, Per	4,705
45	x	x	0	64.5	0.2	Dakota Sand, CreU	S	x	784	24	AF	Ignacio Quartzite, Cam	7,397
46	x	x	0	36.2	0.9	Yates, Queen, Grayburg, Per	LS	x	465 1,904	x	A	San Andres, Per	2,905
47	x	x	0	42.0	0.1	Mesa Verde, CreU	S	x	438	13	AF	Mesa Verde, CreU	971
48	1,397	x	0	35.0	1.0	Seven Rivers, Per	S	x	3,056	x	A	San Andres, Per	4,115
49	x	x	0	34.5	0.9	Grayburg, Per	S	x	3,919	80	A	San Andres, Per	4,359
50	x	x	0	38.0	0.8	Yates, Per	SL	x	788	x	A	San Andres, Per	2,500
51	x	x	0	26.0	0.9	Yates, Seven Rivers, Per	LS	x	3,018	48	A	Queen, Per	3,825
52	x	x	0	36.0	1.0	Yates, Per	S	x	3,935	30	A	Yates, Per	4,460
53	x	x	0	33.0	0.9	Yates, Queen, Per	S	x	3,450	x	A	San Andres, Per	4,890
54	x	x	0	36.0	1.0	Grayburg and Abo, Per	L	x	3,800 7,700	50 75	A	Pre Cambrian, Gra.	10,465
55	1,420	x	0	37.4	1.0	Grayburg, Per	S	x	3,525	x	A	San Andres, Per	4,052
56	1,455	943	0	33	1.0	Seven Rivers, Per	D	Cav	3,775	70	A	Yeso, Per	6,602
57	1,670	888	0	33	1.0	San Andres, Per	L	x	4,350	x	A	San Andres, Per	5,501
58	x	x	0	33.5	1.0	Queen, Grayburg, Per	L & S	x	3,946	62	A	San Andres, Per	4,840

The Maljamar area was extended by McLaughlin and Cosden when they completed their State No. 1 for 76 bbl. of oil in 9 hr. in the Grayburg lime of Permian age.

Production in Lea County during 1944 was 33,509,548 bbl., with Monument producing 7,543,789 bbl., Eunice 6,376,772, Vacuum 5,018,303 and Hobbs 4,092,629. The total recovery for the Hobbs pool at the end of 1944 was 108,825,939 bbl., or 10,880 bbl. per acre.

Eddy County

Drilling during 1944 accounted for only one gas discovery and one oil area extension in Eddy county. Martin Yates III Stebbins No. 1, sec. 29-20-29, was completed as a gas well with an initial production of 5700 M cu. ft. at a depth of 728 ft., after being plugged back from 931 ft. in the Yates section of Permian age. The extension was made to the Artesia area by Stanley Jones when he completed his State No. 1 for an initial production of 25 bbl.

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
59	Square Lakes, *Eddy*	1941	6,840	2,522,236	1,134,601	80	3,263	1,500*x*	173	42	0	167	2	0
60	Table Mesa, *San Juan*	1925	100	660,780	22,146	0	*x*	*x*	6	0	0	0	6	0
61	Tocito Dome, *San Juan*	1943	0	0	0	40	0	0	1	0	0	0	0	1
62	Tonto, *Lea*	1944	40	7,404	7,404	0	5	5	1	1	0	1	0	0
63	Turkey Track, *Eddy*	1943	280	10,414	9,689	0	*x*	*x*	7	6	0	6	1	0
64	Ute Dome, *San Juan*	1921	0	0	0	640	9,891	864	3	0	0	0	0	3
65	Vacuum, *Lea*	1929	28,520	26,522,405	5,010,035	0	23,194	5,224	400	13	0	219	137	0
66	West Eunice, *Lea*	1928	920	1,136,796	366,996	0	65	36	23	4	0	9	14	0
67	West Lovington, *Lea*	1944	680	0*x*	0*x*	0	*x*	*x*	17	17	0	17	0	0
68	West Lusk, *Eddy*	1941	160	70,230	16,911	0	*x*	*x*	4	1	0	0	4	0

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Reservoir Pressure, Lb. per Sq. In.: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
59	950	700*x*	0	37.8	0.8	Grayburg, Per	S	*x*	3,012	25	A	Abo, Per	6,587
60	*x*	*x*	0	57.0	0.03	Dakota sand, CreU	S	*x*	1,325	12	A	Chinle, TriU	3,010
61	*x*	*x*	0			Ouray lime, Dev	L	*x*	6,659	21	D	Ignacio Quartzite, Cam	6,919
62	*x*	*x*	0	34.0	1.0	Seven Rivers, Per	L	*x*	3,565	21	A	Queen, Per	4,295
63	*x*	*x*	0	37.0	0.9	Queen, Grayburg, Per	L, S	*x*	2,575	25	A	San Andres, Per	3,896
64	720	400	0			Dakota sand, CreU	S	*x*	2,285	60	D	Dakota, CreU	2,590
65	1,630	1,072	0	35.5	1.0	San Andres, Per	D	Cav	4,316	*x*	A	San Andres, Per	5,329
66	*x*	*x*	0	31.0	1.0	Seven Rivers, Per	L	*x*	3,773	51	A	San Andres, Per	4,695
67	1,775	1,735	0	36.8	0.9	Seven Rivers, Per	L	Cav	4,750	75	A	San Andres, Per	5,183
68	*x*	*x*	0	26.0	0.9	Yates, Per	L	*x*	2,509	20	A	Seven Rivers, Per	2,763

TABLE 2.—*Summary of Drilling Operations in New Mexico*

Important Wildcats Drilled in 1944

Line Number	County	Location: Survey	Location: Lat.	Location: Long.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U.S. Bbl.	Initial Production per Day: Gas, Millions Cu.Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. Per Sq. In.: Casing	Pressure, Lb. Per Sq. In.: Tubing	Remarks
1	Chaves	35	14-S	17-E	4,014	Permian	Pre-Cambrian	Humble O. & R.						Dry hole
2	De Baca	26	4-N	24-E	5,553	Permian	Pennsylvanian	Frank Griggs						Dry hole
3	De Baca	27	4-N	22-E	1,785	Permian	Yeso, Permian	M. Staniforth						Dry hole
4	Eddy	2	18-S	25-E	2,168	Permian	San Andres Permian	Malco Refineries, Inc.						Dry hole
5	Eddy	14	18-S	27-E	2,060	Permian	Grayburg Permian	Stanley L. Jones	25	?	1			Extension Artesia area
6	Eddy	29	20-S	29-E	931	Permian	Yates, Per	M. Yates, III et al.		5.7				Gas discovery, Getty area
7	Eddy	5	20-S	31-E	2,470	Permian	Seven Rivers, Permian	N. H. Wills						Dry hole
8	Eddy	2	20-S	31-E	2,489	Permian	Seven Rivers, Permian	Stanolind Oil & Gas Co.						Dry hole
9	Eddy	15	20-S	31-E	2,850	Permian	Seven Rivers, Permian	The Texas Co.						Dry hole
10	Eddy	24	20-S	31-E	2,963	Permian	Queen Permian	The Texas Co.						Dry hole
11	Eddy	36	21-S	27-E	2,655	Permian	Delaware, Permian	M. Yates III et al.						Dry hole
12	Eddy	23	22-S	24-E	3,905	Permian	Delaware, Permian	Std. Oil Co. of Texas						Dry hole
13	Eddy	3	22-S	25-E	3,248	Permian	Delaware, Permian	Std. Oil Co. of Texas						Dry hole
14	Eddy	9	25-S	28-E	3,043	Permian	Delaware, Permian	Engas Co.						Dry hole
15	Lea	10	11-S	35-E	5,505	Tertiary	San Andres, Permian	Magnolia Petr. Co.						Dry hole
16	Lea	1	12-S	34-E	4,994	Tertiary	San Andres, Permian	Humble O. & R.						Dry hole
17	Lea	25	11-S	35-E	5,130	Tertiary	San Andres, Permian	Devonian Oil Co.						Dry hole
18	Lea	4	17-S	36-E	5,175	Tertiary	San Andres, Permian	Fred Turner, Jr.	344	?	⅛			Discovery, West Lovington area
19	Lea	22	19-S	33-E	3,586	Tertiary	Seven Rivers, Permian	The Texas Co.	295	0.262	2			Discovery, Tonto area
20	Lea	5	19-S	33-E	4,305	Tertiary	Queen, Permian	Carper Drlg. Co.						Dry hole
21	Lea	2	17-S	32-E	4,049	Tertiary	Grayburg, Permian	McLaughlin Cosden	203	Pump	2			Extension Maljamar area
22	Lea	15	19-S	34-E	5,070	Tertiary	San Andres, Permian	Culbertson & Irwin						Dry hole
23	Lea	5	20-S	38-E	4,284	Tertiary	San Andres, Permian	DeKalb Agric. Assn.						Dry hole
24	Lea	8	20-S	38-E	7,955	Tertiary	Abo(?) Permian	DeKalb Agric. Assn.		3				Shut-in gas well P.B. to 4055
25	Lea	23	20-S	37-E	10,465	Tertiary	Pre Cambrian	Continental Oil Co. et al.	270	?	¾			New pay horizon, Skaggs area, P.B. to 7725
26	Lea	16	20-S	38-E	3,315	Tertiary	Yates Permian	DeKalb Agric. Assn.						Dry hole
27	Lea	9	21-S	34-E	4,130	Tertiary	Seven Rivers, Permian	Skelly Oil Co.						Dry hole
28	Lea	19	22-S	35-E	4,500	Tertiary	Yates, Permian	Tidewater Assoc. Oil Co.						Dry hole
29	Lea	30	22-S	38-E	6,508	Tertiary	Yeso, Permian	Gulf Oil Corp.	1,398	1.050	¾			Discovery, Drinkard area
30	Lea	12	26-S	37-E	11,969	Tertiary	Ellenburger, Ordovician	Humble O. & R.	190	0.329	5/32			Discovery, Dublin area
31	Roosevelt	21	2-S	30-E	3,410	Permian	Yates, Permian	W. J. Peterman						Dry hole
32	San Miguel	1	16-N	12-E	1,005	Permian	Pre Cambrian	Great Lakes Carbon Corp.						Dry hole

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944	75	23
Number of oil wells completed during 1944	283	6
Number of gas wells completed during 1944	12	2
Number of dry holes completed during 1944	67	36

of oil per day from 1850 ft., in the Grayburg section of Permian age.

The largest producing field in Eddy County during 1944 was Grayburg Jackson, with 1,979,331 bbl.; followed by Square Lakes with 1,134,601 bbl. and Loco Hills with 1,117,252. The greatest recovery to date has been the Grayburg Jackson area with 15,495,196 barrels.

Secondary Recovery

In Southeastern New Mexico four plants were in operation returning residue gas to the producing formation. These plants were having a marked success in reducing formation-pressure drop and in extending the flowing life of the wells, with the possibility of greater ultimate oil recovery. The plants were operating in the Loco Hills, Langlie, Maljamar and Grayburg-Jackson fields.

Northwestern New Mexico

Hospah dome was the leading oil-producing field in northwestern New Mexico in 1944, with production of 320,231 bbl., followed by Hogback with 65,886 and Rattlesnake with 53,079. Gas production of 1,597,072 M. cu. ft. from Fulcher Basin, 1,422,024 M. cu. ft. from Barker Creek dome led the gas fields.

On Barker Creek dome the Southern Union Gas Co. was drilling a deep test that by the end of the year had penetrated the Hermosa section of the Pennsylvanian formation at a depth of 7630 ft. and was drilling ahead. This is the deepest test to date in northwestern New Mexico. No new discoveries were recorded in this area during 1944 and drilling was in the main part confined to known structures.

Acknowledgment

The author gratefully acknowledges the help of Mr. Raymond F. Miller, of the New Mexico Oil Conservation Commission, Artesia, N. M., in the compilation of data and general assistance.

Oil and Gas Developments in New York in 1944

By C. A. Hartnagel*

During the past 10 years the annual production of petroleum in New York has averaged close to 5,000,000 bbl., the total for the period being 49,881,000 bbl. In 6 of the 10 years, the production was slightly in excess of the 5,000,000 mark. The 1944 production of 4,697,000 bbl. represents a 7 per cent decline from the previous year. Of the total 1944 output, the Allegany County district, which includes two small areas of Steuben County, contributed 3,614,065 bbl., a decline of 5 per cent from 1943, and the contribution of Cattaraugus County, which represents the northern extension of the Bradford pool of Pennsylvania into New York was 1,082,935 bbl., a decline of more than 14 per cent.

Since March 1942, the posted price of New York crude oil has remained at $3.00 per bbl. On Aug. 1, 1944, a Federal subsidy of 75¢ per bbl. was granted to oil producers, thus making the price actually $3.75 per bbl. Since all of the oil produced in New York comes under the designation "stripper well operations," it is entitled to the Federal subsidy.

During the last few years there has been little change in the number of wells drilled annually. In the Allegany field, which accounts for three fourths of the oil produced in the state, 1240 wells, including water-intake wells, were drilled during 1944 as compared with 1223 in 1943. There was no marked increase in the number of wells drilled after granting the subsidy of 75¢ per bbl. of oil on Aug. 1, the increase being but 14 wells during the last half of the year over the preceding six months. In flooding operations it is not to be expected that even a substantial increase in the price of crude oil will be reflected quickly in an increase of the number of wells drilled or in a marked increase in production of crude oil. In flooded areas, oil is obtained through a program extending over a number of years. This program involves the drilling of the water or input pressure wells, drilling of the oil wells, building up the oil flood to maximum production, and finally the watering out of the well when the amount of oil produced in proportion to the water becomes so small that pumping is no longer profitable. The various operations may extend over a period of 10 years or more, during which time the price of crude may have fluctuated greatly. Although the rate of production can be controlled to a limited extent, it is evident that a flood when once begun must be continued regardless of the price of crude. During the past seven years New York crude has had a price range from $1.68 per bbl. in 1938 to the present price of $3.75 per barrel.

The field pattern now in general use for wells in a flood project is the "five-spot." Under this arrangement, the lease is divided into squares with a water well at each corner and an oil well in the center. In the all-over pattern of the lease each oil well is acted upon by four water wells and each water well supplies part of the pressure to four oil wells. Spacing between the input water wells and the oil wells usually varies from 200 to 225 ft. or, on an acre basis, there is one oil well and one water well for each 2½ acres. In recent years there has been a tendency to increase

Manuscript received at the office of the Institute April 4, 1945.

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the distance between input water wells and the oil wells. As a result of this practice, a longer period of time is required to recover the oil, but the time factor is offset by increasing the pressure through the use of water pumps.

Pressures exerted on the sand face may be as high as 1600 lb. per sq. in. The depths of New York oil wells vary from 450 ft. to about 2100 ft., and the pressure that can be applied to the sand is limited by the weight of the overburden. Excessive pressure actually will raise the overburden, thus causing a parting of the formation through which the water may pass quickly to an oil well.

Water for Flooding

When it is realized that 7 to 8 bbl. of water is required to produce 1 bbl. of oil, the importance of a year-round water supply for flooding operations will be appreciated. In the early history of flooding, water was obtained by raising, cutting or shooting the casing of an old oil well and allowing the subsurface water to enter the well. The pressure thus established was limited to the natural hydrostatic pressure of the water column. Silt and cavings in the well had a tendency to clog the sand. With the introduction of pressure pumps and a rapid increase in flooding operations, large quantities of filtered and chemically treated water became necessary. Fortunately, the average annual precipitation in the New York oil district is 37 in., with a high of 47 and a low of 30 in. Moreover, with the exception of a limited area, the entire region is glaciated and the old stream valleys are deeply filled with unconsolidated sediments. These sediments are the source of water for a number of centrally located water-pressure plants, which are comparable to the water systems of moderate sized cities. The larger plants sell water to a number of leases, delivering the purified water at high pressures to the water-intake wells.

Natural Gas

During 1944, as for several years past, the search for new supplies of gas in the Oriskany sandstone has continued. The necessity for finding new supplies is shown by the fact that from a maximum production, largely from the Oriskany sandstone, of 39 billion cubic feet of gas in 1938, the output has gradually decreased to about 8 billion cubic feet annually, only a little more than the average production before the discovery of gas in the Oriskany sandstone.

The net result of the drilling of 19 wildcat wells, distributed in 13 townships of Allegany, Steuben, Chemung, Schuyler and Wyoming Counties, was the discovery of one good producer, the Sherman J. Frazier in Tuscarora township, Steuben County, which came in with an initial production of 9,000,000 cu. ft. of gas. Several wells in close proximity to the Frazier are now in process of drilling (March 1945).

Among the noteworthy developments of the year was the drilling of two deep wells, the K. R. Wilson in Wyoming County, 6757 ft. deep and not yet completed, and the old Herrington in the Woodhull field, an Oriskany well, deepened during 1944 to 8625 ft.—the deepest well ever drilled in New York state.

Of the 19 wells drilled during the past year, four were in Allegany County and all encountered salt water. Three of these were on the outskirts of the Beech Hill field, but no indication of gas was recorded in the Oriskany sandstone. The fourth well, near the northern town line of Alma township, had a reported flow of 117,000 cu. ft. of gas, which was drowned out by a column of 3000 ft. of salt water. This well was located ¾ mile southwest of a wildcat in Wellsville township, drilled in 1943 with comparable results, and less than 2 miles north of a third well (1939) that found only salt water.

In Steuben County, nine tests were made. Three within the limits of the

TABLE 1.—*Wildcat Tests, mostly Oriskany, in Southwestern New York during* 1944

County and Township	Name of Well	Operator	Elevation, Ft.	Tully, Ft.	Top Onondaga, Ft.	Top Oriskany, Ft.	Total Depth, Ft.	Remarks
Allegany								
1. Alma.......	Katharine Vossler	Allegany Gas Co., Empire Prod. Corp., Hanley and Bird	2,034	4,206–4,254	4,749	4,790	4,795	117 M cu. ft. gas, but 3,000 ft. salt water
2. Independence	James Clark Est.	Empire Prod. Corp.	2,186	4,232–4,285	4,833	4,874	4,877	At 4,877 ft. hole filled 1,200 ft. with salt water in 14 hours
3. Independence	Earl Green*	Empire Gas and Fuel Co.	2,291	4,339–4,387	4,967–5,011	5,015–5,020	5,020	Transitional zone 5,011–5,015 ft. Salt water at 5,020 ft. No gas
4. Willing.....	William Burrows	Cunningham & Coyle	2,082	4,257–4,308	4,830	4,860	4,865	Salt water at 4,863 ft.
Steuben								
5. Bath.......	H. N. Donaldson	Appalachian Dev. Co.	1,128	2,048–2,085	2,853	2,874	2,874	Flow of salt water
6. Bath.......	Archie Thompson	Appalachian Dev. Co.	1,145	1,934	2,730	2,743	2,749	375 M cu. ft. gas at 2,748 ft., but salt water filled hole 2,350 ft. in 40 hours
7. Bradford....	Cratsley (State of New York)	N. Y. S. N.G.	1,689	2,304–2,349	3,248	3,281–3,309	3,323	No gas, no water
8. Canisteo....	George Coots	Allegany Gas Co.	2,307	3,953–3,994	4,596	4,656	4,665	Small show of gas in Oriskany. 2,200 ft. salt water at 4,665 ft. Onondaga reported as very shaly at 4,596 ft. Hard at 4,644 ft.
9. Greenwood..	Warriner No. 2	Appalachian Dev. Co.	1,896	3,673–3,719	4,320	4,366–4,372	4,372	At 4,372 ft. well filled 225 ft. with salt water in 1 hour. No gas
10. Greenwood..	S. Murray No. 2	Belmont Q. D.	2,314	4,174–4,227	4,816	4,859	4,863	19 M cu. ft. gas at 4,860 ft., but salt water rose 2,500 ft. in 3 days
11. Greenwood..	William Hyland	Appalachian Dev. Co.	2,348	4,138–4,182	4,782	4,820	4,822	Salt water at 4,822 ft.—3 bailers per hour
12. Troupsburg.	Roger Lozier No. 2	N. Y. S. N.G.	1,834	4,015–4,067	4,734	4,760–4,784	4,798	No gas, no water
13. Tuscarora...	Sherman J. Frazier	Sylvania	1,194	3,052–3,108	3,877	3,902–3,907	3,907	9 MM cu. ft. gas at 3,907 ft. 2,010 lb. rock pressure in 2 hours
14. Woodhull...	Herrington	New Penn	1,546	3,147	3,914	3,955	Old-3,957 New-8,625	Completed to Oriskany by Atwater et al. in 1937; 17 MM cu. ft. gas. 1943–1944 deepened by New Penn, Niagara 6,270, Red Medina 6,886 ft., Queenston shale 7,066 ft., Oswego sand 7,965 ft. Show gas, 8 M cu. ft. at 7,025 and 7,036 ft.
Chemung								
15. Elmira.....	Falsey Lot	Beecher et al.	858	1,472–1,546			2,720	At 2,310 ft., between Tully and Onondaga, 260 M cu. ft. shale gas, which declined to 52 M cu. ft. This gas being produced instead of drilling to Oriskany, since well was low in Tully.
16. Elmira.....	George Richard	Updegraff	850	1,523	2,703	2,753–2,783	2,800	Show of gas at 2,758 ft.
17. Veteran.....	A. M. Beebe No. 2	D-Y-M Corp.	1,264	1,685–1,752	2,892	2,959–2,993	2,994	No show of gas
Schuyler								
18. Hector......	T. Allen No. 1	Belmont Q. D.	1,594	1,359–1,381	2,369	2,419	2,429	Show of gas. 300 ft. salt water in 12 hours
Wyoming								
19. Arcade.....	K. R. Wilson No. 1	K. R. Wilson	1,474	1,750–1,769	2,140	2,215–2,274?	6,757, Still drilling	Red Medina at 3,290 ft.; White Medina at 3,346–3,365 ft.; Trenton at 5,265 ft. show gas 6,030 ft.; 25 M cu. ft. gas at 6,182 ft. (Oriskany reported, but not verified)
20. Arcade.....	Bigelow No. 1	K. R. Wilson	?	1,780–1,805	2,128	2,278–2,285?	3,375	Red Medina 3,345–3,373 ft. White Medina at 3,373 ft. 5,000 cu. ft. gas in Red Medina. Abandoned, October, 1944. (Oriskany reported, but not verified)

* Completed January, 1945.

Greenwood gas field proved unsuccessful. One wildcat in each of two townships, Bradford and Troupsburg, found neither gas nor water. A well in Canisteo was reported to have had a showing of gas, but a large volume of salt water developed. In Bath township two wells were drilled, one of which produced only salt water. The second had an initial flow of 375,000 cu. ft. of gas, but salt water filled the hole. Further exploratory drilling is under way in this township. The successful producer in Tuscarora township is in the northwest corner of the township, ⅝ mile east of the Woodhull town line and 1½ miles east of the most easterly wells in the Woodhull field.

Three wells in Chemung County and one in Schuyler failed to produce gas. Two wells in Arcade township, Wyoming County, owned by K. R. Wilson, were reported as having small flows of gas in the Red Medina. The first of the Arcade wells, the K. R. Wilson, in the village of Arcade, had at last report (February 1945) reached a depth of 6757 ft. The Trenton, recorded at 5265 ft., had a reported thickness of 928 ft., followed by the Little Falls dolomite, 6193 to 6566 ft. Normally the Little Falls dolomite is followed below by the Potsdam sandstone resting upon the pre-Cambrian. Laboratory studies have not yet been made of samples below the Little Falls dolomite. The second Arcade well of K. R. Wilson, 1½ miles north of the first, and known as the Bigelow, was drilled as a Medina test. This well reached a depth of 3375 ft. with only a small flow of gas in the Red Medina.

An Oriskany test completed in 1937, the Herrington well in the Woodhull field, was drilled during 1943–1944 to a final depth of 8625 ft. and bottomed in the Oswego sand—the deepest well on record in New York state. In the Red Medina, at depths of 7025 and 7036 ft., respectively, small flows of gas were reported. The well was shot with 65 quarts. Four and one-half hours after the shot, the gas flow tested 4500 cu. ft. of gas; five days later, 4800 cu. ft. After being shut in 72 hr., the rock pressure registered 17 lb. The well was abandoned.

There have been no new developments in the old Trenton fields in the central part of the state or in the Medina fields of western New York. In these fields a few wells are drilled from time to time to augment local supplies. Several of the older Medina fields and two or three of the Oriskany fields are used for the underground storage of gas. If additional supplies of gas can be obtained from without the state, underground storage will be greatly increased.

Of considerable interest to local natural-gas operators is the recent erection at Olean, N. Y., of a plant for the manufacture of high-grade gasoline from dry natural gas. The pilot-plant operations are reported to be very successful, one barrel of gasoline being obtained from about 10,000 cu. ft. of gas.

Oil and Gas Development in Ohio in 1944

By Kenneth Cottingham,* Member A.I.M.E.

The number of completions in 1944 in Ohio was only slightly greater than completions in the preceding year, but the initial daily volumes both of oil wells and gas wells declined considerably. The dry-hole ratio was a little lower than in 1943, even though in the year under review considerable effort was made to find new production. No new areas of consequence were discovered. Thirteen new gas pools, the largest of which was 1000 acres and the average 565 acres, were opened during the year. Eleven of these pools were in the Clinton sand, one was in the Oriskany, and one was in the Berea. Approximately 15 small pools might also be rated as discoveries, but because only one or two wells have thus far been completed in each, they cannot at present be properly evaluated. The latter pools average about 120 acres each. Some extensions were made to existing gas pools.

The number of oil wells drilled was only one less than in 1943, yet compared with the year 1941, when twice as many oil wells were drilled, the difference is startling. Effective Aug. 1, 1944, a blanket subsidy was granted of 35¢ per barrel on all Cleveland-Chatham, Corning, and Lima grades of oil, and 75¢ per barrel on Pennsylvania grade crude. The subsidy was authorized by the Office of Price Administration, with reimbursement to purchasers of the various grades made through the Defense Supplies Corporation, a branch of Reconstruction Finance Corporation.

For several years the small operator, particularly the owner of stripper wells, was in a serious position. The subsidy has been a means of real help and, in addition to aiding the operator, it has prolonged the life of many small wells that otherwise would have been abandoned, with consequent loss of daily production and unrecovered reserves. It is questionable whether the price increase is sufficient to revive production of Corning grade, which has

Table 1.—*Wells Drilled during* 1944 *in Ohio*

Sand	Oil Wells		Gas Wells		Number of Dry Holes	Total Number Drilled
	Number of Wells	Average Initial Daily per Well, Bbls.	Number of Wells	Average Initial Daily per Well, M Cu. Ft.		
Shallow	36	18	33	308	47	116
Berea	53	11	125	187	75	253
Ohio shale			6	89	5	11
Oriskany	1	4	20	908	13	34
Newburg	2	21	3	504	0	5
Clinton	67	36	285	1,085	245	597
Trenton	10	7	6	4	6	22
Sub-Trenton					2	2
Total	169	23	478	769	393	1040

Manuscript received at the office of the Institute April 5, 1945.

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declined about 30 per cent in the four-year period of 1940 to 1944.

TABLE 2.—*Completions in Ohio in* 1944

County	Oil Wells	Gas Wells	Dry Holes	Total
Ashland	8	13	21	42
Athens	9	25	14	48
Carroll			1	1
Columbiana	4	6	8	18
Coshocton	7	4	16	27
Cuyahoga		6	5	11
Darke		1		1
Fairfield	1	6	6	13
Fulton		1		1
Gallia		12	5	17
Geauga			3	3
Guernsey	2	9	12	23
Harrison			1	1
Henry	1	1		2
Hocking	3	4	8	15
Holmes	3	28	22	53
Jackson			4	4
Jefferson	1	3	1	5
Knox	5	4	11	20
Lake		3	1	4
Lawrence		6	3	9
Licking	14	4	4	22
Logan		2		2
Lorain		35	27	62
Mahoning			2	2
Medina	4	34	24	62
Meigs	8	16	6	30
Mercer	4	2		6
Monroe	13	21	22	56
Morgan	1	26	21	48
Muskingum	16	43	35	94
Noble	6	28	19	53
Perry	40	23	29	92
Preble			1	1
Putnam			1	1
Richland			2	2
Seneca			1	1
Stark		50	4	54
Summit	1	17	12	30
Tuscarawas		19	11	30
Vinton			1	1
Washington	12	19	18	49
Wayne	1	7	8	16
Wood	5		3	8
Total	169	478	393	1040

TABLE 3.—*Production of Oil in Ohio in* 1944

Grade	Number of Wells	Barrels
Pennsylvania	11,626	1,656,455
Lima	6,800	205,211
Corning	3,356	810,246
Cleveland-Chatham	1,276	381,682
Total	23,058	3,053,594

Present secondary recovery projects, now numbering about twelve in Ohio, will be increased. Plans under way for installing additional equipment, both repressuring and water drive, are temporarily delayed because of shortage of critical material and manpower. The Engineering Department of the Pennsylvania Grade Crude Oil Association is taking an active part in preliminary investigation of secondary recovery in the Pennsylvania grade areas of Ohio. In the field of research, the Engineering Experiment Station of The Ohio State University has completed plans for working with and assisting the oil industry in the state.

TABLE 4.—*Number of Completions in Ohio,* 1940–1944

Year	Oil		Gas		Dry		Total
	Number	Per Cent	Number	Per Cent	Number	Per Cent	
1940	327	26.63	491	39.98	410	33.39	1,228
1941	333	21.33	701	44.91	527	33.76	1,561
1942	181	17.96	471	46.72	356	35.32	1,008
1943	170	16.73	455	44.78	391	38.49	1,016
1944	169	16.25	478	45.96	393	37.79	1,040
Total	1,180	20.16	2,596	44.35	2,077	35.49	5,853

GENERAL ACTIVITY

In number of wells drilled, the most active Clinton development was in Muskingum County, where 39 gas wells, 15 oil wells and 35 dry holes were completed. Most of the wells were in Falls township (20 completions) and Wayne township (23 completions). The largest gas well in the county was in Falls township, and gauged 5240 M cu. ft. when completed. Perry County, with 14 gas wells, 32 oil wells and 20 dry holes, was second. Clayton township, with 18 Clinton drillings and Hopewell township, with 11, were most active. Medina County, 33 gas, 1 oil and 24 dry, was the third most active county. Of the total Clinton completions in the county, 21 were in Granger township and 11 in Hinckley. Lorain, Stark and Holmes Counties followed in order. The record of Stark County with 49 gas wells and only 4 dry holes, is notable for Clinton drilling. The initial open flow of the 49 wells averaged 1160 M cu. ft. per well, while the average depth was about 4700 feet.

Oriskany completions were greater in number than in 1943, but the wells were much smaller in volume. In 1943 the average was 1392 M cu. ft. per well. Of the 16 Oriskany wells in Guernsey County, 7 were in Liberty township, 5 in Wheeling and 4 in Knox townships. Summit County was prominent in Oriskany exploration, with 7 wells in Bath and 3 in Richfield townships. The depth of the Oriskany wells in Summit County averages 2094 feet.

TABLE 5.—*Annual Oil Production in Ohio, 1940–1944*

Year	Production, Bbl.	Number of Oil Wells	Average per Well, Bbl.
1940	3,169,000	25,500	124
1941	3,510,000	24,801	142
1942	3,664,000	24,080	152
1943	3,442,000	23,335	148
1944	3,053,594	23,058	132

TABLE 6.—*Annual Production and Consumption of Natural Gas in Ohio, 1939–1943*

Year	Annual Production, M Cu. Ft.	Annual Consumption, M Cu. Ft.
1939	36,469,000	114,720,000
1940	40,639,000	129,856,000
1941	41,858,000	136,251,000
1942	45,055,000	144,325,000
1943	52,001,000	162,371,000

TABLE 7.—*Prices of Crude Oil in Ohio during 1944*

Grade	Posted Price, 12-31-43	Date of Change and Amount	Posted Price, 12-31-44
Pennsylvania	$2.55		3.30[a]
Pennsylvania (Zanesville)	2.15 + 0.10	(2-1-44)	3.00[a]
Lima	1.50		1.85[b]
Corning	1.31		1.66[b]
Cleveland-Chatham	1.30		1.65[b]

[a] O.P.A. subsidy increase of 75¢, Aug. 1, 1944.
[b] O.P.A. subsidy increase of 35¢, Aug. 1, 1944.

Noble County led in Berea drilling, with 25 gas, 2 oil and 13 dry. Most of the activity was in Enoch and Noble townships. The shallow sands, at least a dozen of which are important, all lie above the Berea. Washington County, with 40 shallow tests, and Monroe County with 31, led all other areas.

HORIZONS TESTED

The total depth of the 647 oil and gas wells was 1,660,992 ft. When the dry holes are included, the total depth of the 1040 wells completed during the year is 2,722,637 feet.

Clinton wells formed approximately 57 per cent of all wells drilled. The total footage of the 597 Clinton tests was 2,094,862. None of the Clinton wells was conspicuous from the viewpoint either of location or depth. The deepest well completed during the year was the Texas Company-Mizer No. 1, in sec. 32, Stock township, Harrison County, which was dry in the Clinton and abandoned at a depth of 6301 ft. In Marietta township, Washington County, the East Ohio-Hall No. 3 in sec. 17 was dry in the Clinton and abandoned at a depth of 5089. The H. K. Porter-Richey No. 1, sec. 29, Rich Hill township, Muskingum County, had a show of gas in the Clinton (Medina) but was abandoned at a depth of 4779.

The largest gas wells discovered during 1944 in the Clinton gauged identical initial volumes. In sec. 16, Lake township, Ashland County, in an area which has produced from the Berea, Robinson and others completed the Kapp No. 5 with an initial open flow of 12,000 M cu. ft. at a depth of 2975 ft. The Ohio Fuel Gas Company-Parker No. 1 in tract 12, Huntington township, Lorain County, also gauged 12,000 M cu. ft. at 2449 in the Clinton. The Harmon-Griggs No. 2, likewise in Huntington township, had an initial open flow of 9800 M cu. ft. at a depth of 2460.

The largest Clinton oil well was the Pure Oil-Wilson No. 4 in sec. 12, Reading township, Perry County. This well, in the westward extension of the Clayton pool, had an initial daily production after shot

of 133 bbl. The total depth was 3220 ft. Two other large wells in Clayton township, Perry County, were the Preston Oil-Loveberry, sec. 5, with 115 bbl. at 3106, and the Preston Oil-Yarger, in the same section but ¼ mile southeast of the Loveberry. The Yarger well had an initial production of 105 barrels.

TABLE 8.—*Comparison of Berea and Clinton Drilling in Ohio*

Year	Berea Completions				Clinton Completions			
	Oil Wells		Gas Wells		Oil Wells		Gas Wells	
	Number of Completions	Average Initial per Well, Bbl.	Number of Completions	Average Initial per Well, M Cu. Ft.	Number of Completions	Average Initial per Well, Bbl.	Number of Completions	Average Initial per Well, M Cu. Ft.
1940	184	8	125	105	57	44	229	967
1941	178	6	150	188	80	111	325	1,092
1942	43	10	86	168	88	77	273	904
1943	44	7	89	214	86	66	276	1,237
1944	53	11	125	187	67	36	285	1,085
Total.....	502	8	575	171	378	69	1,388	1,062

Berea wells, including the Second Berea, constituted about 24 per cent of the total completions. The over-all of the 253 Berea wells was 326,069 ft. In sec. 17, Pike township, Stark County, at a total depth of 808 ft., the Belmont Quadrangle-Leiser No. 1 had an initial volume of 3000 M cu. ft. This well later was being drilled to the Clinton. In sec. 3, Bedford township, Meigs County, the Ohio Fuel-Logan and Clark found 2590 M cu. ft. in the Berea at a depth of 1618. In lot 37, Washington township, Tuscarawas County, the Frank Lyons-Wm. Porter No. 1, at a depth of 1010 in the Berea, gauge dinitially 2000 M cu. ft. Two Preston Oil Company's wells, both in sec. 3, Bedford township, Meigs County, each had an initial production of 65 barrels.

The Shallow Sand wells, averaging 1003 ft. in depth, reached a total footage of 116,302. In 1944, these wells represented about 11 per cent of the total completions. In sec. 15, Ludlow township, Washington County, the Ludlow Oil and Gas Co. completed a Big Injun well having an initial of 180 bbl. at a depth of 1370 ft. This well, ¾ mile east of Flint's Mill, lies in the heart of the old field of that name, which was discovered in the year 1899.

The Oriskany completions, about 3 per cent of the total Ohio drillings, reached a total footage of 103,059. Only one Oriskany well is noteworthy, and that is the Ohio Oil-Barnett No. 1 in sec. 14, Knox township, Columbiana County. After shot, this well gauged 5800 M cu. ft. with the pay at 3545 to 3557. In sec. 25, Lawrence township, Washington County, the Sinclair-Hill No. 4 logged Oriskany sand from 5121 to 5184, but it was nonproductive and the well was drilled to a depth of 5205 ft. and abandoned.

Other Completions

The Trenton completions were one less than the total for 1943. The deepest Trenton well was the Ohio Oil-Chaney No. 2, sec. 20, Clark township, Coshocton County. This well found the Trenton from 4733 to 5660, but the formation was dry and the well was abandoned at the last-named depth. In sec. 14, Miller township, Knox County, the C. A. Davis-Bonsell No. 2 went through the Trenton and was abandoned at a depth of 4463 ft. In sec. 29, Liberty township, Putnam County, the Ohio Oil Co. found the Trenton from 1436

to 2053 and the St. Peter from 2063 to 2070. The well was nonproductive and was abandoned at a depth of 3377 ft. In sec. 1, Ruggles township, Ashland County, the Ohio Oil-Kraus No. 1 had a good show of gas and some oil in what was probably the St. Peter at 4461. The well was continued to a depth of 5251 ft., but when filled back and acidized no way was found to exclude bottom water and the well was plugged in March 1945.

The first rotary well drilled in Ohio was begun in September 1944 by the Texas Company on the Gillespie farm, in sec. 4, Union township, Belmont County. In spite of particularly hard drilling in the cherty section in the Devonian limestone and upper Silurian, and slow progress in the Clinton, the well was completed in March 1945 at a depth of 7455 ft. in the Queenston shale, where it was abandoned.

New Pools

Little can be reported as to discoveries of new producing areas. In Dover township, Tuscarawas County, an area of about 1000 acres was proved in the Clinton sand. The gas wells averaged only 750 M cu. ft. initial open flow, while the depth is about 5000 ft. In LaGrange township, Lorain County, a Clinton pool of 750 acres, containing seven wells, was opened. In the southwest quarter of the northeast quarter of Huntington township, Lorain County, about 700 acres was proved in the Clinton. In Bath township, Summit County, about 650 acres was proved by Oriskany development.

Extensions were made to about 15 pools, prominent ones being in northeast Bethlehem, southeast Perry and southwest Canton townships, all in Stark County, where about 2000 acres was added to the existing Clinton pool. In northwest Pike township, Stark County, 12 Clinton wells added some 2200 acres to the pool. The Clinton pool in northeast Granger township was extended, a small portion entering south-central Hinckley township in Medina County. The area of this pool was increased about 1500 acres. The Clinton area in eastern Killbuck township, Holmes County, was extended northward when eight wells were completed, the added territory being about 1000 acres.

No oil territory of consequence was added. In sec. 4, Pike township, Coshocton County, the E. Bucy-Mizer No. 1 made 75 bbl. from the Clinton at 3000 ft. This is a somewhat isolated well and may lead to further development. In sec. 13 of the same township, the A. Willey-Ashcraft also made 75 bbl. from the Clinton at a depth of 3203 ft. This is an outpost well on the north edge of the old Clinton pool in southwestern Pike township.

Acknowledgment

As in many past reviews of Ohio development, the writer had the assistance of Mr. D. T. Ring, Vice President of the Preston Oil Co. Associates of the Ohio Fuel Gas Co., particularly Mr. J. R. Lockett, Geologist, and Mr. A. W. Johnson, gave valuable help for which the writer is deeply appreciative.

Oil and Gas Development in Oklahoma in 1944

By Raymond D. Sloan,* Member A.I.M.E.

During 1944, substantial gains were recorded in practically every phase of the petroleum industry in Oklahoma. With the spotlight of activity focused on other states during the more recent years, the production momentum that was achieved in Oklahoma through the discovery and development of such outstanding pools as Oklahoma City, Fitts, and major pools in the Seminole area during the late 1920's and early 1930's was practically spent by the end of 1943. However, with much of the industry's exploratory efforts greatly reduced in Illinois, Indiana and Kentucky, the strong demand for Mid-Continent crude and the optimism created by some discoveries in the state toward the end of 1943, Oklahoma has again become the recipient of much activity and interest, with its 1944 drilling activity, production and refinery runs to stills registering substantial gains over the preceding year.

Development and Exploration

Since the discovery of the West Edmond pool in April of 1943, with the subsequent drilling and development boom, the scene of exploratory activity has shifted from the central, south and east portions of the state to the general trend of the Granite Ridge, where leasing and wildcatting were greatly activated within a wide radius of this high subsurface feature. Leasing activity, however, jumped the confines of the Granite Ridge trend and extended into all of the northwestern counties in the state.

Seismograph activity at once began following and keeping pace with this shift in the leasing and exploration locale, by the concentration of a large number of seismograph crews in the area. At one time during the year, 35 crews were concentrated in Oklahoma, the majority being west of the Granite Ridge and extending into the northwestern counties. To illustrate the increase in geophysical work done in the state during the year, records indicate that 377 crew months were worked in 1944, which is a 21 per cent increase over the 311.5 crew months activated in 1943.

With the discovery in 1943 of several encouraging prospects and the finding of West Edmond as an incentive, drilling operations increased some 54.3 per cent, for a total of 1986 completions during the year. This is compared with a figure of 1287 for wells drilled in 1943, an increase of 699 wells. The industry, with a total of 1064 oil producers, enjoyed a success percentage of 53.6 per cent. Gas wells completed were 223, while 699 dry holes were drilled. In 1943, completions included 587 oil wells, 127 gas wells, and 573 dry holes. The number of oil producers completed during the year was almost double the number of wells in 1943.

Of the total drilling wells completed in the state, 350, or 17.6 per cent, were wildcat operations—an increase of 5.1 per cent over the 1943 total of 333. The wildcat success percentage was 13.4 per cent, 47 successful wells being completed for an average initial potential of 160 bbl. In the state, 23 gas wells were completed with an average initial production of

Manuscript received at the office of the Institute April 23, 1945.
* The Carter Oil Co., Tulsa, Oklahoma.

9166 M cu. ft. of gas, while 280 (80 per cent) were dry.

The working over of old wells contributed an initial potential of 8200 bbl. from 109 successful workovers out of a total of 185 attempts. In addition to the 109 oil wells, 31 gas wells were completed and the remaining 54 were abandoned.

The 47 wildcat oil wells drilled resulted in the opening of 34 new pools; but none of these discoveries, judging from current development, is to be considered of major importance. Of these discoveries, the more important are the Southwest Lone Grove pool in 5S. 1W., Carter County; the East Pauls Valley pool in 3N. 1E., Garvin County; South Moore pool, 10N. 3W., Cleveland County; and, the Washington pool, sec. 4–7N. 3W., McClain County.

Southwest Lone Grove.—Discovered in May 1944, in the NW. NW. SW. of sec. 5, 5S. 1W., 15 producing oil wells and two dry holes were completed by the end of the year, and the pool had eight active operations on Jan. 1. Production (36° gravity) is from the Deese sand at a depth of 2775′, and at the close of the year it had amounted to 199,000 bbl. Current production during December for the field's 15 wells averaged 1,623 bbl. daily.

East Pauls Valley.—The East Pauls Valley field in sec. 13, 3N. 1E, Garvin County, shared in the state's development to the extent of 31 producing oil wells and four dry holes. This field, with a proved productive area of 1760 acres, produces 33° gravity oil from a Pennsylvanian sand at an approximate depth of 3000 ft. Total 1944 production amounted to 242,000 bbl. With 21 active operations at the beginning of 1945, a sizable concentration of the coming year's activity may be expected in this field.

South Moore.—The South Moore pool, of Cleveland County, was discovered in June of 1944 in the NE. SW. SW. of sec. 26, 10N. 3W., where production was developed from the Wilcox sand at 8833 to 8865 ft. In December the Bartlesville sand was developed as a productive horizon from 7742 to 7772 ft., the discovery well initialing 750 bbl. of 35° gravity oil through open tubing. It now appears that the Bartlesville sand will be the most prolific of the two producing horizons.

Washington.—The Washington pool, a McClain County discovery by The Carter Oil Co. in the SE. SW. of sec. 4, 7N. 3W., produces from the Second Wilcox sand from 10,635 to 10,645 ft., and initialed 200 bbl. of 39° gravity oil.

New Horizons in Old Fields

Production was developed in four old pools in the state from new productive horizons, as follows: In the Blakely pool, 12N. 10E., Okfuskee County, Booch sand production was developed; in the West Moore pool of Cleveland County, which originally produced from the Wilcox sand, production was found in the Hunton lime, which initialed 570 bbl. of oil in 17 hr. through a 1-in. tubing choke; in the Wewoka pool, in 8N. 8E., a small well was completed in the Booch sand at 2975 ft.; also in the Wheeler pool, of Carter County, a Deese sand well was completed for an initial potential of 30 bbl. daily from a depth of 5066 feet.

Gas Developments

The outstanding gas development in the state during 1944 was in the Tri-state Hugoton gas area, where 85 wells were completed on the Oklahoma side for an average initial potential of 24,062,000 cu. ft. Oklahoma came into its own as a commerical gas-producing state during the year, having increased its Hugoton production some 318 per cent. Although the pool extends into three states, Oklahoma showed the largest increase, where withdrawals increased from 10,374,054 M cu. ft. in 1943 to the sum of 43,290,965 M cu. ft. in 1944.

TABLE 1.—*Oil and Gas Production in Oklahoma*

Line Number	Field, County[a]	Year of Discovery	Oil Production			Number of Oil and/or Gas Wells[f]			Oil Wells Producing[g] Dec. 1944[1]	
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Completed to End of 1944	1944		Artificial Lift	Total
				To End of 1944	During 1944		Completed	Abandoned		
	CENTRAL OKLAHOMA									
1	Agra, West, *Lincoln*	1927	80	254,505	30,872		1		4	4
2	Avery, *Lincoln*	1939	120	15,063	1,979				1	1
3	Chandler, *Lincoln*	1924	1,255	12,578,893	246,459		5		50	50
4	Davenport, *Lincoln*	1924	2,335	12,442,576	154,242	222			112	112
5	Davenport, North, *Lincoln*	1941	130	66,808	4,476				4	4
6	Davenport, South, *Lincoln*	1926		211,198	4,314				2	2
7	Davenport, West, *Lincoln*	1940	50	141,289	16,059				5	5
8	Gessman, *Lincoln*	1934	160	448,363	19,296				9	9
9	Hoyt, *Lincoln*	1935	265	1,438,052	42,267				9	9
10	Kendrick, *Lincoln*	1940	40	59,209	7,432				2	2
11	Laffoon, *Lincoln*	1932	470	2,446,205	185,405					12
12	Lincreek, *Lincoln*	1932	275	256,441	5,124				8	8
13	McLoud, North, *Lincoln*	1943	160	87,932	52,316	4			3	3
14	Meeker, South, *Lincoln*	1943	80	14,278	8,730	1			1	1
15	Payson, *Lincoln*	1940	40	19,018	3,203				1	1
16	Peck, *Lincoln*	1926	160	626,849	50,214				5	5
17	Perkins, *Lincoln*	1940	150	258,400	30,399				2	2
18	Sac and Fox, *Lincoln*	1924–37	1,830	3,657,716	148,685				139	139
19	Skellyville, *Lincoln*	1925	310	1,835,745	20,118				12	12
20	Sporn, *Lincoln*	1936	150	801,631	34,009				6	6
21	Sporn, East, *Lincoln*	1942	10	14,233	6,583				1	1
22	Stroud, *Lincoln*	1923	590	9,382,333	159,681				24	24
23	Warwick, East, *Lincoln*	1944	200	313	313	1	1			1
24	Warwick, Southeast, *Lincoln*	1944	200	14,251	14,251	2	2			2
25	Wellston, North, *Lincoln*	1936	500	1,507,426	27,820				9	9
26	Wilzetta, *Lincoln*	1934	220	1,237,864	47,226				11	11
27	Wilzetta, South, *Lincoln*	1936–42	120	459,080	125,540					6
28	Miscellaneous, *Lincoln*		280	556,600	12,213				5	5
29	Blackburn, East, *Pawnee*	1920		*x*	6,588				5	5
30	Casey, *Pawnee*	1921		*x*	4,665				2	2
31	Cleveland, *Pawnee*	1904	4,255	40,569,402	132,492				215	215
32	Greenup, *Pawnee*	1926		*x*	0	Abandoned				
33	Hallett, *Pawnee*	1922	1,665	*x*	22,692				40	40
34	Jennings, *Pawnee*	1916	1,375	4,150,131	52,704				67	67
35	Keystone, *Pawnee*	1919	5,565	2,889,514	126,270				223	223
36	Lauderdale, *Pawnee*	1915	4,300	13,966,713	182,268				174	174
37	Maramec, *Pawnee*	1920	1,990	3,390,855	131,028				78	78
38	Masham, *Pawnee*	1924	290	*x*	5,856				5	5
39	Pawnee, East, *Pawnee*	1941	10	8,731	0	Abandoned				
40	Ralston, *Pawnee*	1924	205	*x*	0	Abandoned				
41	Skedee, *Pawnee*	1926	160	238,336	14,850				7	7
42	Terlton, *Pawnee*	1912	980	923,448	13,542				13	13
43	Terlton, North, *Pawnee*	1917	2,010	3,301,927	40,260				71	71
44	Watchorn, *Pawnee*	1922	530	7,712,933	66,360				15	15
45	Watchorn, East, *Pawnee*	1942	820	2,343,366	886,901	24	2			24
46	Miscellaneous, *Pawnee*		360	*x*	1,098				1	1
47	Broyles, *Payne*	1918–39	170	*x*	50,508		3			8
48	Broyles, East, *Payne*	1940	110	34,422	0	Abandoned				
49	Coyle, *Payne*	1938–40	1,338	7,011,404	1,215,711					35
50	Coyle, North, *Payne*	1942	80	48,954	8,561				1	1
51	Garr, *Payne*	1920	1,135	2,857,096	114,558				31	31
52	Glencoe	1943	40	21,433	2,558	Abandoned 1944				
53	Ingalls, *Payne*	1914	1,110	6,413,667	90,768		2		25	25
54	Ingalls, East, *Payne*	1943	120	231,285	216,811	4	3			4
55	Ingalls, Northeast, *Payne*	1925		14,634	12,444				6	6
56	Ingalls, Northwest, *Payne*	1944	120	24,119	24,119	1	1			1
57	March, *Payne*	1922	1,410	*x*	69,906				19	19
58	March, North, *Payne*	1926	155	*x*	21,228				7	7
59	Markham, *Payne*	1928	260	69,052	4,352				4	4
60	Markham, West, *Payne*	1943	40	28,345	15,315	2			2	2
61	Mehan, *Payne*	Prior to 1925	670	2,340,318	1,100				3	3

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Accurate figures on flowing and artificial lift not available. "Total" includes all wells, irrespective of method of production.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
			CENTRAL OKLAHOMA							
1										
2		44	Prue, Pen							
3		38	Various, Pen, Ord	S, L	Por	3,250		A		
4		43	Various, Pen	S	Por	2,600	50	ML		
5		41	Prue, Pen	S		3,535	13			
6										
7		46	Prue, Pen	S						
8		44	Cleveland, Pen	S	Por			M		
9		40	1st Wilcox, Ord	S	Por					
10		50	Prue, Pen							
11		22	Wilcox, Ord	S	Por	4,190		A	Wilcox	
12		46	Wilcox, Ord	S	Por	x				
13		37	Wilcox, Ord	S		5,635	6		Wilcox	5,638
14		38	Wilcox, Ord	S		5,544	3		Wilcox	5,545
15		35	Lower Skinner, Pen							
16		23	2nd Wilcox, Ord							
17		43	Hunton, Sil							
18		46	Prue, Pen	S						
19		41	Various, Pen, Sil, Ord, Cam	S, L						
20		46	Simpson, Ord	S		4,500				
21			Upper Simpson, Wilcox, Ord	S		4,555	10			
22		41	Various, Pen, Ord	S	x	4,240	50		Wilcox	4,520
23	175	42	Prue, Pen	S		4,003	12		Prue	4,043
24			Cleveland, Pen	S		3,475	23		2nd Wilcox	5,250
25		40	Wilcox, Ord	S		4,003	12			
26		40	Hunton, Viola, Sil, Dev, Ord							
27		35	Hunton, Viola, Bartlesville, Sil, Dev, Pen, Ord							
28		41	Prue, Wilcox, Pen, Ord	S						
29										
30										
31		36	Various, Pen, Ord, Cam	S, L	Por	1,300				
32		37								
33		38	Various, Pen, Ord							
34		37	Various, Pen, Mis, Ord	S, L	x					
35		37	Various, Pen, Mis, Ord	S, L		1,100				
36		37	Various, Pen, Ord, Cam	S, L		1,185				
37		37	Various, Pen			2,400				
38		39	Various, Pen, Mis, Ord	S, L						
39		42	Misener, Mis			3,363	4			
40		39	Various, Pen, Ord							
41		40	Bartlesville, Burgess, Skinner, Pen	S						
42		38	Various, Pen, Ord							
43		38	Various, Pen, Ord							
44		41	Various, Pen, Mis, Ord	S, L	Por					
45			Wilcox, Ord	S		3,880	15			
46		37	Bartlesville, Wilcox, Pen, Ord	S						
47		43	Bartlesville, Viola, Wilcox, Pen, Ord	S, L						
48		36								
49		46	Hunton, Wilcox, Sil, Ord	S, L	x					
50			Hunton, Sil, Dev	L		4,751	9			
51		38	Various, Pen, Mis, Ord	S, L						
52		42	Misener, Mis	S		4,029	19		Wilcox	4,121
53		39	Various, Pen, Mis, Ord	S, L		3,115				
54		44	Misener, Mis	S		3,750	6		Viola	3,776
55		41								
56	620	45	2nd Wilcox, Ord	S		4,033	8		2nd Wilcox	4,041
57		38	Various, Pen, Ord							
58		43	Wilcox, Ord	S						
59			Burgess Sd., Mis Ls., Pen-Mis	S, L		3,266	13			
60		42	Wilcox, Ord	S		3,584	2		Wilcox	3,585
61		43	Various, Pen, Mis, Sil-Dev, Ord							

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[1]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[1]: Total
62	Mehan, Northeast, *Payne*	1941	330	366,909	274,836		9			17
63	New Cushing, *Payne*	1916	185	*x*	0	Abandoned				
64	Norfolk, *Payne*	1916	785	*x*	22,692				20	20
65	Norfolk, West, *Payne*	1929	390	*x*	52,704				22	22
66	Orlando, *Payne*	1929	210	1,052,752	25,119					2
67	Orlando, East, *Payne*	1941	80	213,513	22,392		1		3	3
68	Ramsey, *Payne*	1938–40	630	9,418,451	1,243,784	42				41
69	Ripley, *Payne*	1923	375	*x*	13,176				5	5
70	Ripley, North, *Payne*	1923	165	2,274,629	19,238				2	2
71	Stillwater, *Payne*	1935	130	542,081	6,367				3	3
72	Stillwater, West, *Payne*	1940	150	202,753	17,897					1
73	Yale-Quay, *Payne*	1914	4,095	23,845,616	587,064		1		160	160
74	Miscellaneous, *Payne*		160	*x*	3,062				7	7
75	Aggregate for district of pools marked *x*			610,417						
76	Total Central Oklahoma			193,443,234	7,283,070					1,815
	EAST CENTRAL OKLAHOMA									
77	Hoffman, *McIntosh*	1917	300	*x*	124				2	2
78	Hill (Misc'l.), *McIntosh*		10	85	0				1	1
79	Beland, *Muskogee*	1906	390	*x*	184				10	10
80	Boyle, *Muskogee*	1927	230	*x*	6,588				15	15
81	Boynton, *Muskogee*	1914	2,740	*x*	12,810				20	20
82	Butler, *Muskogee*	1918	1,500	*x*	21,228				57	57
83	Cole, *Muskogee*	1914	780	*x*	4,026				20	20
84	Council Hill, *Muskogee*	1919	335	*x*	15,738				31	31
85	Haskell, *Muskogee*	1909	1,750	*x*	24,522				68	68
86	Jolly-Patton, *Muskogee*	1920	260	*x*	732	Abandoned			19	19
87	Link, *Muskogee*	1909	715	*x*	40,626				32	32
88	Muskogee, *Muskogee*	1904	3,760	*x*	34,404				120	120
89	Muskogee, North, *Muskogee*	1906	290	*x*	2,196	Abandoned			22	22
90	Robinson, *Muskogee*	1915	280	*x*	306				2	2
91	Sheppard, *Muskogee*	1917	140	*x*	1,830				1	1
92	Sommerville, *Muskogee*	1926		*x*		Abandoned				
93	Transcontinental, *Muskogee*	1918	215	*x*	2,196				7	7
94	Yahola, *Muskogee*	1914	680	*x*	2,196				18	18
95	Miscellaneous, *Muskogee*		820	*x*	15,614				10	10
96	Baltimore, North, *Okfuskee*	1922	525	*x*	3,294				7	7
97	Bearden, *Okfuskee*	1924		*x*		Abandoned				
98	Beidleman, *Okfuskee*	1930	100	281,128	4,137				5	5
99	Blakely, *Okfuskee*	1924	160	904,844	44,432				5	5
100	Carey, *Okfuskee*	1923	485	1,178,103	24,594				10	10
101	Clearview, *Okfuskee*	1927	240	*x*	17,202				10	10
102	Clearview, Northwest, *Okfuskee*	1942	40	1,625	155				1	1
103	Cowan, *Okfuskee*	1940	80	40,051	6,499				2	2
104	Deaner, *Okfuskee*	1920	1,460	*x*	75,396				78	78
105	Fields, *Okfuskee*	1918	460	*x*	10,614				10	10
106	Gregory, *Okfuskee*	1922	390	*x*	15,372				14	14
107	Gypsy Hill, *Okfuskee*	1910	1,603	*x*	12,078				13	13
108	Haydenville, *Okfuskee*	1939	240	129,933	17,224				4	4
109	Josey, *Okfuskee*	1923	525	*x*	48,312				18	18
110	Keaton, *Okfuskee*	1919	210	*x*		Abandoned				
111	Lyons-Quinn, *Okfuskee*	1921	1,645	*x*	41,724				24	24
112	Mason, *Okfuskee*	1940	10	8,515		Abandoned				
113	Micawber, *Okfuskee*	1923	160	*x*	4,392				1	1
114	Midwest, *Okfuskee*	1942	90	85,052	8,770				4	4
115	Morgan, *Okfuskee*	1923	340	*x*	1,830				1	1
116	Morse, *Okfuskee*	1944	40	1,089	1,089	1	1		1	1
117	Okemah, *Okfuskee*	1921	1,050	*x*	74,298				50	50
118	Okemah, East, *Okfuskee*	1940	160	410,570	45,269				7	7
119	Okemah, North, *Okfuskee*	1941–42	160	233,876	52,413				10	10
120	Okemah, West, *Okfuskee*	1941	60	49,736	2,298				1	1

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
62		47	1st and 2nd Wilcox, Ord			4,065 4,100	11 3			
63		38	Various, Pen, Ord							
64		38	Bartlesville, Wilcox, Pen, Ord	S						
65		38	Bartlesville, Wilcox, Pen, Ord	S						
66		41	Misener, Mis	S						
67		41	Misener, Mis	S		4,720	27			
68		42	1st Wilcox, Ord	S		4,768	27			
69		42	Various, Pen, Ord	S, L						
70		42	Wilcox, Ord	S	Por					
71		40	Wilcox, Ord	S	Por	4,300	6	A		
72		41	Hunton, Sil							
73		38	Oswego, Bartlesville, Wilcox, Pen, Ord	S, L		2,670				
74		39	1st and 2nd Wilcox, Ord							
75										
76										
			EAST CENTRAL OKLAHOMA							
77		35	Wilcox, Ord	S						
78		40								
79		35	1st and 2nd Dutcher, Pen	S						
80		38	Dutcher, Pen	S						
81		35	Mississippian, Mis	L						
82		32	Unidentified Sand							
83		35	Unidentified Sand							
84		38	Various, Pen							
85		34	Tucker, Pen							
86		43	Muskogee, Timber-Ridge							
87		36	Booch, Dutcher, Pen							
88		38	Unidentified sand Wilcox, Ord	S		1,052				
89		35	Wilcox, Ord	S						
90		39	Muskogee							
91		39	Unidentified sand							
92										
93		39	Booch, Pen	S						
94		39	Booch, Boynton, Pen							
95		38	Leidecher, Dutcher, Wilcox, Pen, Ord							
96		38	Dutcher, 1st and 2nd Wilcox, Pen, Ord							
97										
98		38	Wilcox, Ord	S						
99		39	Unidentified Sand							
100		32	Various, Pen							
101		38	Wilcox, Ord	S						
102			Gilcrease, Pen	S		2,915	10			
103		42	Hunton, Sil-Dev							
104		38	Deaner, Lyons, Wilcox, Pen, Ord	S		2,800				
105		43	Deaner, Wilcox, Pen, Ord	S						
106		39	Various, Pen, Ord							
107		33	Youngstown, Dutcher, Wilcox, Pen, Ord	S		2,430				
108		31	Dutcher, Wilcox, Pen, Ord	S						
109		40	Wilcox, Ord	S		3,600	50	D	Wilcox	3,700
110		39	Dutcher, Quin, Pen							
111		39	Lyons, Pen							
112		39	Hunton, Sil-Dev							
113		36	Wheeler, Dutcher, Pen							
114		36	Hunton, Sil-Dev	L		3,692	4			
115		37	Dutcher, Pen							
116			Cromwell, Pen			3,176	6			
117		30	Gilcrease, Cromwell, Pen							
118		37	Lower Cromwell, Pen							
119		42	Gilcrease, Hunton, Pen, Sil-Dev							
120		44	Hunton, Sil-Dev			3,916	44			

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Total Production, Bbl.[c]: To End of 1944	Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	1944: Completed	1944: Abandoned	Oil Wells Producing[g] Dec. 1944[1]: Artificial Lift	Total
121	Okfuskee, *Okfuskee*	1938	100	143,486	8,424				5	5
122	Paden, *Okfuskee*	1914	80	*x*	1,830				3	3
123	Paden, North, *Okfuskee*	1944	40	2,010	2,010	1	1		1	1
124	Pettiquah, *Okfuskee*	1942		32,456	27,204		8		11	11
125	Sheldon, *Okfuskee*	1916	900	*x*	25,620				14	14
126	Weleetka, *Okfuskee*	1913	1,815	*x*	141,642		4		74	74
127	Weleetka, South, *Okfuskee*	1937	90	62,493	1,266				3	3
128	Weleetka, West, *Okfuskee*	1926	250	1,012,038	69,514				15	15
129	Miscellaneous, *Okfuskee*		340	*x*	15,714				4	4
130	Aztec, *Okmulgee*	1917	2,140	*x*	40,626				42	42
131	Bald Hill, *Okmulgee*	1908	25,095	*x*	293,166				719	719
132	Belts-Rapp, *Okmulgee*	1920		*x*		Abandoned				
133	Beggs, North, *Okmulgee*	1909	1,840	*x*	13,542				21	21
134	Beggs, South, *Okmulgee*	1911	4,455	*x*	62,586				43	43
135	Brinton, *Okmulgee*	1914	545	*x*	9,516				15	15
136	Coalton, *Okmulgee*	1907	2,040	*x*	19,764				57	57
137	Edna, East, *Okmulgee*	1919	150	*x*	2,196				2	2
138	Eram, *Okmulgee*	1921	600	*x*	3,294				14	14
139	Gypsy Hill, Northwest, *Okmulgee*	1938	100	71,275	4,914				4	4
140	Hamilton Switch, *Okmulgee*	1909	2,570	*x*	24,888				73	73
141	Hector, *Okmulgee*	1914	645	*x*	1,464				7	7
142	Henryetta, *Okmulgee*	1910	785	*x*	7,320				32	32
143	Henryetta, Northeast, *Okmulgee*			*x*	4,392				4	4
144	Montezuma, *Okmulgee*	1918	220	*x*	3,660				4	4
145	Morris, *Okmulgee*	1907	7,300	*x*	93,696				208	208
146	Natura District, *Okmulgee*	1914	1,750	*x*	9,516				18	18
147	Nuyaka, South, *Okmulgee*	1937	105	531,602	12,924				6	6
148	Nuyaka, Southwest, *Okmulgee*	1941	40	29,410	3,723				2	2
149	Oklahoma Central, *Okmulgee*	1921	545	*x*	9,150				8	8
150	Okmulgee District, *Okmulgee*	1906	5,020	*x*	55,998				136	136
151	Phillipsville, *Okmulgee*	1920	580	*x*	6,222				7	7
152	Pine, *Okmulgee*	1915	815	*x*	3,660				26	26
153	Pollyanna, *Okmulgee*	1921	3,975	*x*	103,944				187	187
154	Schulter, *Okmulgee*	1907	455	*x*	3,660				9	9
155	Simmons-Black, *Okmulgee*	1920	455	*x*	16,104				10	10
156	Spencer, *Okmulgee*	1917	790	*x*	18,300				31	31
157	Summers, *Okmulgee*	1914	290	*x*	2,928				15	15
158	Tiger Flats, *Okmulgee*	1928	1,045	*x*	155	Abandoned				
159	Youngstown, *Okmulgee*	1915	2,235	*x*	21,960				44	44
160	Miscellaneous, *Okmulgee*		465	*x*	1,002				2	2
161	Airport, *Tulsa*	1937	330	145,021	1,565				12	12
162	Alsuma, *Tulsa*	1916	175	*x*	2,928				4	4
163	Bird Creek, *Tulsa*	1906	17,910	*x*	327,204				1,475	1,475
164	Bixby, *Tulsa*	1916	1,860	*x*	24,156				70	70
165	Broken Arrow, *Tulsa*	1901	3,665	*x*	20,862				55	55
166	Bruner Vern, *Tulsa*	1923	1,055	*x*	36,234				50	50
167	Collinsville, *Tulsa*	1916	120	*x*	2,196				10	10
168	Dawson, *Tulsa*	1906	765	*x*	10,248				40	40
169	Fisher, *Tulsa*	1918	685	*x*	3,660				7	7
170	Jenks, *Tulsa*	1901	6,885	*x*	71,370				293	293
171	Leonard, *Tulsa*	1916	1,000	*x*	13,908				32	32
172	Owasso, *Tulsa*	1913	360	*x*	5,124				13	13
173	Perryman, *Tulsa*	1924	345	*x*	1,464				10	10
174	Red Fork, *Tulsa*	1901	4,390	*x*	21,228				78	78
175	Sand Springs, *Tulsa*	1916	625	*x*	18,666				41	41
176	Tulsa, *Tulsa*	1901	910	*x*		Abandoned—1943				
177	Turkey Mountain, *Tulsa*	1922	1,115	*x*	25,986				49	49
178	Turley, *Tulsa*	1914	3,715	*x*	78,690				349	349
179	Wicey, *Tulsa*	1915	2,200	*x*	47,214				83	83
180	Bilby, *Wagoner*	1918	260	*x*	2,562				7	7
181	Corine, *Wagoner*	1919	190	*x*	732				7	7
182	Coweta, *Wagoner*	1914	720	*x*	6,222				23	23
183	George, *Wagoner*	1918	270	*x*	7,320				33	33
184	Gillette, *Wagoner*	1924	65	*x*	1,464				8	8
185	Goble, *Wagoner*	1916	325	*x*	4,758				17	17

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
121		39	Dutcher, Wilcox, Pen, Ord							
122		36	Prue, Pen	S						
123			Cromwell, Pen			3,725			2nd Wilcox	4,557
124										
125		42	Wilcox, Ord							
126		39	Gilcrease, Pen	S		2,530	130			
127		39	L Gilcrease, Pen	S						
128		41	Booch, Pen	S						
129		36	Various, Pen, Ord							
130		38	Booch, Wilcox, Pen, Ord	S						
131		30	Glenn, Pen	S		750				
132										
133		38	Youngstown, Wilcox, Pen, Ord							
134		37	Various, Pen, Mis, Ord							
135		37	Wilcox, Ord	S						
136		30	Booch, Wilcox, Pen, Ord	S		1,300				
137		30	Unidentified Sand							
138		40	Wilcox, Ord	S						
139			Wilcox, Ord	S		3,250	10			
140		29	Glenn, Dutcher, Wilcox, Pen, Ord	S		1,385				
141		37	Various, Pen, Mis, Ord	S, L						
142		38	Various, Pen, Sil-Dev, Ord, Cam	S, L						
143										
144		38	Unidentified Sand							
145		36	Various, Pen, Mis, Ord	S, L		1,600				
146		30	Various, Pen, Mis, Ord							
147		43	Wilcox, Ord	S						
148			Misener, Mis			3,168	8			
149		32	Wilcox, Ord	S						
150		30	Various, Pen, Mis, Ord	S		1,240				
151		45	Wilcox, Ord	S						
152		35	Booch, Dutcher, Pen	S						
153		34	Various, Pen, Ord, Cam	S, L		1,365				
154		36	Deaner, Glenn, Wilcox, Pen, Ord							
155		36	Salt, Booch, Pen							
156		33	Various, Pen, Mis, Ord, Cam							
157		38	Dutcher, Pen	S						
158		37	Various, Pen, Ord							
159		31	Youngstown, Pen	S						
160		40	Booch, Dutcher, Wilcox, Pen, Ord	S						
161		38	Bartlesville, Pen	S						
162		35	Burgess, Pen	S						
163		31	Bartlesville, Wilcox, Pen, Ord	S		1,110				
164		32	Various, Pen, Ord	S, L						
165		37	Various, Pen, Mis, Ord, Cam							
166		37	Various, Pen, Ord, Cam							
167		33	Various, Pen, Mis	S, L						
168		36	Bartlesville, Tucker, Pen	S						
169		34	Oswego, Tyner, Arbuckle, Pen, Ord, Cam							
170		36	Various, Ord, Cam, Pen, Mis	S, L						
171		35	Various, Pen, Mis, Ord, Cam	S, L						
172		30	Various, Pen, Ord, Cam							
173		31	Unidentified Sand							
174		34	Various, Pen, Ord, Cam			599				
175		37	Various, Pen, Ord, Cam							
176		34	Various, Pen, Mis, Ord							
177		35	Various, Pen, Ord, Cam							
178		32	Bartlesville, Burgess, Siliceous, Pen, Ord, Cam	S, L		1,260				
179		37	Various, Pen, Mis, Ord	S, L		1,480				
180		35	Dutcher, Burgess, Pen							
181		39	Unidentified Sand							
182		38	Various, Pen, Mis, Ord, Cam	S, L		700				
183		36	Dutcher, Pen	S						
184		38	Tyner, Ord							
185		37	Dutcher, Pen	S						

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
186	Johnson-Bailey, *Wagoner*	1920	80	*x*		Abandoned				
187	McCracken, *Wagoner*	1920	90	*x*					12	12
188	Oak Grove, *Wagoner*	1920	145	*x*		Abandoned				
189	O. K., *Wagoner*	1919	80	*x*		Abandoned				
190	Oneta, *Wagoner*	1916	695	*x*	18,666				57	57
191	Seltzer, *Wagoner*	1924	65	*x*	512				11	11
192	Stone Bluff, *Wagoner*	1915	1,065	*x*	96,990				156	156
193	Striker, *Wagoner*	1917		*x*		Abandoned				
194	Wagoner, *Wagoner*	1914	460	*x*	646				43	43
195	Wagoner, South, *Wagoner*	1939	80	14,564	4,837				8	8
196	Webster, *Wagoner*	1917	60	*x*	1,098				11	11
197	Wright, *Wagoner*		80	*x*					1	1
198	Miscellaneous, *Wagoner*		170	*x*	2,431				7	7
199	Aggregate for districts of pools marked *x*			312,761,300						
200	Total East Central Oklahoma			318,130,262	2,705,147					5,679
	EAST CENTRAL CREEK COUNTY									
201	Arno	1923	210	*x*	30,744				13	13
202	Arno, Southeast	1923		*x*	15,557				7	7
203	Arno, West	1940	227	159,425	22,563		2		6	6
204	Bellview, South	1941	50	106,370	23,459				6	6
205	Big Pond	1924	470	*x*	120,780				30	30
206	Bowden	1906	3,495	*x*	109,800				212	212
207	Bristow	1916	5,255	*x*	282,552				123	123
208	Bristow, North	1922	1,700	*x*	88,938				92	92
209	Bristow, West	1922	565	*x*	17,934				10	10
210	Bruce	1926	515	*x*	32,208				39	39
211	Bruce, East	1939	100	*x*	6,222				9	9
212	Cushing	1912	24,940	368,342,139	2,925,438	3,708	12		1,691	1,691
213	Deep Fork	1920	3,345	*x*	142,374		6		124	124
214	Depew	1915	1,365	*x*	326,838				72	72
215	Donnelly	1924	730	*x*	69,540		1		35	35
216	Edna	1940	90	113,113	12,614				5	5
217	Glenn Pool	1905	15,970	225,948,375	2,134,146		28		1,788	1,788
218	Hickory Grove	1942	220	91,643	23,101		1		15	15
219	Independent	1908	1,320	*x*	51,240				31	31
220	Iron Post	1917	925	*x*	23,790				57	57
221	Kellyville	1934	3,600	*x*	119,682				178	178
222	Manford (Deep and Shallow)	1922–37	4,650	*x*	178,242				221	221
223	Mercer	1923	80	310,601	7,777				4	4
224	Milfay	1941	640	116,312	38,190		1			3
225	Mounds	1915	1,580	*x*	17,934				32	32
226	Newby	1929	80	*x*	3,660				4	4
227	Olean	1921	340	*x*	23,058				18	18
228	Olive	1914	2,235	*x*	102,846				180	180
229	Olive, South	1940	20	2,462	124				1	1
230	Pickett-Prairie	1916	1,820	*x*	6,954				51	51
231	Poor Farm	1920	340	*x*	13,176				13	13
232	Red Bank	1918	370	*x*	20,130				8	8
233	Sapulpa	1909	1,790	*x*	53,070		9		108	108
234	Sapulpa, South	1910	2,570	*x*	72,468				68	68
235	Slick	1913	6,585	*x*	392,718		3		173	173
236	Stroud, East	1940	460	868,102	74,298				34	34

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
186		33	Unidentified Sand							
187		43	Tyner, Ord							
188		33	Pitkin, Burgen, Pen, Ord							
189		36	Dutcher, Tyner, Burgen, Pen, Ord							
190		38	Dutcher, Mis, Tyner, Pen, M Ord	S, L		1,000				
191		37	Dutcher, Pen	S						
192		36	Various, Pen, Mis, Ord, Cam			1,840				
193		35	Dutcher, Morrow-Pitkin, Pen, Mis							
194		35	Peru, Ordivician, Pen, Ord							
195		35	Pennsylvanian							
196		33	Burgen, Ord							
197		40	Pitkin, Pen	L						
198		32	Unidentified sand and lime							
199										
200										
			EAST CENTRAL CREEK COUNTY							
201		36	Simpson, Ord							
202										
203		40	Prue, Red Fork, Bartlesville, Wilcox, Pen, Ord							
204			Red Fork sand, Pen	S		2,756	10			
205		32	Jones, Glenn, Dutcher, Wilcox, Pen, Ord	S						
206		32	Taneha, Pen							
207		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Mis, Wilcox, Pen, Mis, Ord	S, L		2,700				
208		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Mis, Wilcox, Pen, Mis, Ord	S, L						
209		35	Dutcher, Pen			3,152				
210		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Mis, Wilcox, Pen, Mis, Ord							
211		37	Layton, Pen							
212		39	Various, Pen, Ord	S, L	Por			AF		
213		42	Layton, Peru, Prue, Dutcher, Pen							
214		32	Glenn, Dutcher, Wilcox, Pen, Ord	S		2,700				
215		37	Dutcher, 1st Wilcox, Pen, Ord							
216		35	Wilcox, Ord							
217		34	Various, Pen, Ord							
218			Bartlesville, Pen	S		3,119	11			
219		35	Taneha, Wilcox, Pen, Ord	S		2,100				
220		36	Wheeler, Prue, Cleveland, Pen	S		2,420				
221		30	Peru, Pen	S						
222		35	Various, Pen, Ord	S, L		1,550				
223		42	Dutcher, Wilcox, Pen, Ord	S						
224			1st & 2nd Wilcox, Ord	S		3,970	5			
225		33	Red Fork, Glenn, Tucker, Dutcher, Wilcox, Pen, Ord	S		400				
226		34	Dutcher, Pen	S						
227		40	Layton, Peru, Wheeler, Skinner, Bartlesville, Pen	S						
228		36	Various, Pen	S						
229		38	Prue, Pen	S						
230		35	Glenn, Taneha, Wilcox, Pen, Ord							
231		34	Various, Pen							
232		36	Various, Pen, Ord							
233		34	Various, Pen, Mis, Ord	S, L		1,000				
234		36	Taneha, Dutcher, Wilcox, Pen, Ord							
235		32	Various, Pen, Mis, Ord			2,340			Wilcox	3,140
236		41	2nd Wilcox, Pen, Ord							

TABLE I.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
237	Stroud, Southeast	1943	240	703,668	562,908	60	49			53
238	Tibbens	1924	430	*x*	18,666				36	36
239	Tibbens, North	1940	110	104,144	19,494				4	4
240	Tuskegee	1924	310	*x*	2,562				6	6
241	Tuskegee, East	1925	540	1,324,996	102,936				26	26
242	Walker	1923	390	*x*	67,710		3		31	31
243	Walker, West	1939	80	129,848	7,861				7	7
244	Wilcox	1919	1,375	*x*	133,956				54	54
245	Miscellaneous		670	*x*	62,220				26	26
246	Aggregate for district of pools marked *x*			201,203,229						
247	Total Creek County, East Central Oklahoma			799,524,427	8,562,478					5,704
	NORTHEASTERN OKLAHOMA									
248	Craig, Nowata, Rogers, and Washington Counties		104,670	368,999,878	4,357,596				14,840	14,840
	NORTHERN OKLAHOMA									
249	Barnes, *Garfield*	1918	185	*x*	10,248				10	10
250	Brown, *Garfield*	1930	85	464,492	12,475				3	3
251	Enid, *Garfield*	1940	240	97,642	20,305				3	3
252	Garber, *Garfield*	1916	4,520	56,971,418	612,328	999	12		537	537
253	Garber, North, *Garfield*	1927	90	*x*	16,836				8	8
254	Hillsdale, *Garfield*	1938	160	110,985	7,259				1	1
255	Waukomis, *Garfield*	1938	1,040	35,044		Abandoned				
256	Miscellaneous, *Garfield*	1926		70,736	3,389				2	2
257	Caldwell, *Grant*	1929	80	269,325		Abandoned				
258	Deer Creek, *Grant*	1922	210	1,390,777	25,620				10	10
259	Lamont, *Grant*	1937	60	788,843		Abandoned				
260	Webb, *Grant*	1926	120	251,410	14,883				7	7
261	Blackwell, *Kay*	1918	1,750	5,550,782	121,426		2		39	39
262	Braman, *Kay*	1924	335	4,818,317	45,384	154			22	22
263	Braman, North, *Kay*	1924	795	18,816,439	181,902				45	45
264	Braman, Southeast, *Kay*	1938	440	498,540	38,361				4	4
265	Dilworth, *Kay*	1917	2,355	6,018,277	217,038				78	78
266	Hubbard, *Kay*	1924	645	8,783,421	127,368				33	33
267	Mervine, *Kay*	1913	960	*x*	7,686				2	2
268	Newkirk, *Kay*	1919	250	*x*	22,326				6	6
269	Ponca City, *Kay*	1917	1,445	6,645,666	70,272				40	40
270	Thomas, *Kay*	Prior to 1914	275	7,409,545	71,336				12	12
271	Tonkawa, *Kay*	1921	3,695	122,874,279	408,055	931			141	141
272	Tonkawa, South, *Kay*	1921		*x*		Abandoned				
273	Vernon, *Kay*	1925	660	3,750,525	139,812		2		26	26
274	Miscellaneous, *Kay*		290	*x*	6,677				5	5
275	Crescent, *Logan*	1933	2,520	16,170,824	1,205,604	107	27			75
276	Crescent, East, *Logan*	1944	120	27,064	27,046	3	3		3	3
277	Crescent, Northeast, *Logan*	1944	10	3,210	3,210	1	1		Abandoned	
278	Crescent, South, *Logan*	1942	40	50,972	25,278	4	2		4	4
279	Guthrie, *Logan*	1941	620	2,890,311	322,833					31
280	Guthrie Townsite, *Logan*	1942	400	176,116	51,081					2
281	Hull, *Logan*	1934	80	268,209	25,986				3	3
282	Langston, *Logan*	1934	340	1,934,886	117,745				14	14
283	Langston, South, *Logan*	1935	90	53,035	768				1	1
284	Lovell, *Logan*	1928	220	2,751,492	20,130		4		10	10
285	Lovell, South, *Logan*	1934	200	797,973	230,900					12
286	Lovell, Southeast, *Logan*	1944	200	16,158	16,158	2	2			2
287	Lovell, West, *Logan*	1936		95,176		Abandoned				
288	Marshall, *Logan*	1927	740	11,925,718	46,848				21	21

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
237		44	Prue, Pen	S		2,854	80		Prue	2,934
238		34	Various							
239		39	Wilcox, Ord							
240		38	Various, Pen, Ord							
241		39	Various, Pen, Mis, Ord							
242		35	Various, Pen, Mis, Ord	S, L						
243		37	Bartlesville, Pen	S						
244		35	Various, Pen, Ord							
245		39	Prue, Bartlesville, Wilcox, Pen, Ord	S						
246										
247										
			NORTHEASTERN OKLAHOMA							
248		36								
			NORTHERN OKLAHOMA							
249		39	Tonkawa, Layton, Pen							
250		39	Wilcox, Ord	S						
251		40	Mississippian, Mis	L						
252		41	Various, Per, Pen, Ord	S, L	Por	1,100			x	x
253		44	Various, Pen, Ord							
254		39	1st & 2nd Wilcox, Ord	S					x	x
255		53	Marshall Zone	S	x	7,260	20		x	x
256		43	Wilcox, Ord	S	Por		6	A	x	x
257		40								
258		38	Various, Pen, Mis, Ord	S, L		2,900				
259		40	Wilcox, Ord	S	x	5,400	10		x	x
260		42	Various, Pen, Mis, Ord							
261		40	Various, Pen, Ord	S, L		1,600				
262		40	Various, Pen, Ord	S, L						
263		41	Various, Pen, Ord	S, L						
264		40	Arbuckle, Wilcox, Cam-Ord, Ord	S	x				x	x
265		40	Blackwell, Wilcox, Pen, Ord					A		
266		37	Various, Pen, Ord		Por			AF	x	x
267		39	Various, Pen							
268		40	Burbank, Mississippian, Pen, Mis							
269		38	Various, Pen, Mis, Ord	S, L		1,500		A		
270		41	Various, Per, Pen, Ord	S, L	Por			x		
271		42	Various, Pen, Mis, Ord	S, L	Por	2,660		x		
272		42	Endicott, Tonkawa, Wilcox, Pen, Ord							
273		40	Various, Pen, Mis, Ord	S, L				x		
274		39	Various							
275		41	Layton, Wilcox, 2nd Wilcox, Pen, Ord	S	23			AF		
276		39	L. Layton, Pen	S		4,756	14		2nd Wilcox	6,330
277			2nd Wilcox, Ord						2nd Wilcox	6,270
278		43	Layton, Pen	S		5,237	26			
279		46	Bartlesville, 2nd Wilcox, Pen, Ord			{ 5,109 { 5,425	14 20			
280			Dolomite, Wilcox, Ord	S		5,604	8			
281		40	Layton, Tonkawa, Wilcox, Pen, Ord	S	Por					
282		39	Wilcox, Ord	S	Por	5,100		A	Wilcox	5,190
283		40	Upper Simpson, Ord							
284		40	Tonkawa, Wilcox, Pen, Ord	S	x					
285		49	Layton, Pen	S						
286		40	Layton, Pen	S		4,807	26		Layton	4,855
287		40	2nd Wilcox, Ord	S	Por			x		
288		41	Tonkawa, Wilcox, L. Simpson, Pen, Ord	S	x					

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
289	Meridian, *Logan*	1938	240	181,781	4,298				3	3
290	Navina, *Logan*	1941	20	475					1	1
291	Navina, West, *Logan*	1942	320	280,898	44,375				7	7
292	Pleasant Valley (Guthrie, South), *Logan*	1943	80	19,243	17,395	2	1		2	2
293	Seward, *Logan*	1936	40	106,270	14,463		1		2	2
294	Billings, Deep, *Noble*	1935	830	16,513,556	1,490,718	79				73
295	Billings, Shallow, *Noble*	1917	590	6,225,083	6,588				6	6
296	Liberty, *Noble*	1942	160	266,418	35,751 }		2		3	3
297	Liberty, East, *Noble*	1942		239,761	76,822 }					2
298	Lucien, *Noble*	1932	4,170	32,288,292	1,136,430	131	1			121
299	Lucien, North, *Noble*	1936	530	1,368,389	95,880				11	11
300	Lucien, Northeast, *Noble*	1942	160	431,666	128,297					5
301	Marathon, *Noble*	1935	80	138,341		Abandoned				
302	Morrison "A," *Noble*	1942	10	1,987	1,037				1	1
303	Otoe City, *Noble*	1930	240	486,051	131,745				8	8
304	Otoe City, East, *Noble*	1943	200	305,603	231,678					15
305	Otoe City, Southeast, *Noble*	1943	10	724		1			Abandoned	
306	Perry, *Noble*	1923	60	92,145	4,027				1	1
307	Perry, Southeast, *Noble*	1943	40	15,493	5,333	1			1	1
308	Polo, *Noble*	1934	510	4,651,211	153,923				25	25
309	Sams, *Noble*	1925	295	2,346,427	17,202				6	6
310	Sams, Northeast, *Noble*	1943	80	71,822	37,541	3	1		3	3
311	Summer, West, *Noble*	1944	60	90,506	90,506	2	2			2
312	Aggregate for district of pools marked *x*			3,437,252						
313	Total Northern Oklahoma			352,337,001	7,998,582					1,510
	OKLAHOMA CITY AREA									
314	Moore, *Cleveland*	1935	940	9,123,220	207,522	40			22	22
315	Moore, South, *Cleveland*	1944	405	79,788	79,788	3	3			3
316	Moore, West, *Cleveland*	1943	490	292,896	283,284	7	6			7
317	Noble, *Cleveland*	1938	30	74,489		Abandoned				
318	Norman, *Cleveland*	1939	60	13,863		1			1	1
319	Stella, *Cleveland*	1943	10	29,247	7,399	1				1
320	Arcadia, Northeast, *Oklahoma*	1944	270	92,598	92,598	2	2			2
321	Britton, *Oklahoma*	1935	1,245	2,708,432	92,273				19	19
322	Britton, South, *Oklahoma*	1938	195	236,423	38,388				3	3
323	Edmond, *Oklahoma*	1930	1,000	20,789,577	770,090	104				71
324	Edmond, North, *Oklahoma*	1944		1,368	1,368	1	1		1	1
325	Edmond, Northeast, *Oklahoma*	1941	640	598,489	274,233		1			21
326	Edmond, West, *Oklahoma*	1943	31,400	8,205,362	7,731,018	314	299			314
327	Jones, *Oklahoma*	1939	250	227,071	44,452	4			4	4
328	Luther, South, *Oklahoma*	1943	40	2,182	1,729	1			1	1
329	Newalla, *Oklahoma*	1934		3,247		Abandoned				
330	Newalla, South, *Oklahoma*	1939	80	24,137		Abandoned				
331	Nicoma Park, *Oklahoma*	1929	80	364,346	4,998				2	2
332	Oklahoma City, *Oklahoma*	1928	15,500	618,914,373	16,237,956	1,570	4			830
333	Miscellaneous, *Oklahoma*		(2,190)	42,366	14,706	2			2	2
334	Total Oklahoma City Area			661,823,474	25,881,802					1,304
	OSAGE COUNTY									
335	Alameda	1918	1,205	*x*	3,660				69	69
336	Atlantic	1924	1,330	*x*	290,604				88	88
337	Avant	1904	12,520	*x*	789,096				767	767
338	Avant, West	1905	3,555	*x*	42,456				154	154
339	Backius	1919	850	*x*	8,418				32	32
340	Band Wheel	1921	630	*x*	29,280				40	40

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
289		48	Wilcox, Ord	S	*x*	5,200	20			
290		37	1st Wilcox, Ord			6,220				
291			Layton, Pen	S		5,010	33			
292			Skinner, Pen	S		5,683	14		Skinner	5,697
293		38	Simpson, Dolomite, Ord	D						
294		41	Wilcox, Ord	S	Por	4,250		A		
295		41	Various, Pen	S, L	Por		50	A		
296			Tonkawa, Wilcox, Pen, Ord	S		2,374	10			
297			Wilcox, Ord	S		4,508	20			
298		42	Various, Pen, Ord	S, L	Por			*x*		
299		41	Wilcox, Ord	S	Por			*x*		
300			2nd Wilcox, Ord	S		5,389	10			
301		42	Wilcox, Ord	S	Por		34	A		
302			Miss. Ls., Mis	L		4,050	10			
303		39	Layton, Wilcox, Pen, Ord	S	Por	3,284	30	*x*		
304			Tonkawa, Perry, Layton, Pen	S		2,562	188		Wilcox	4,669
305			Burgess	S		4,394	20		Wilcox	4,754
306		41	Tonkawa, Reagan, Pen, Ord							
307			Perry	S		3,494	7		Perry	3,501
308		41	Various, Pen, Ord	S	*x*	4,823		*x*		
309		42	Tonkawa, Pen	S		1,902	10			
310		46	Misener, Dev	S		5,050	14		Wilcox	5,251
311			Wilcox, Ord	S		4,590	7			
312										
313										
			OKLAHOMA CITY AREA							
314		41	Dolomite, U. Simpson, 2nd Wilcox, Ord							
315	1,300	35	Wilcox, Ord	S		8,833	32		2nd Wilcox	9,219
316			Hunton, 2nd Wilcox, Sil, Dev, Ord	L, S		8,787	3		2nd Wilcox	8,800
317		40	2nd Wilcox, Ord	S		7,670	2			
318		38	U. Simpson, Ord	*x*	*x*					
319			Dolomite, Ord			6,498	23		Wilcox	6,603
320	1,330	38	Wilcox, Ord	S		5,971	6		2nd Wilcox	6,510
321		45	Simpson, 2nd Wilcox, Ord	S, D, L	Por			AF		
322		35	2nd Wilcox, Ord	S		6,738	28			
323		39	Simpson, Wilcox, Ord		Por			AF	Arbuckle	7,000
324			Bartlesville, Pen	S		5,980	16			
325		38	Red Fork, Pen	S		5,920	5			
326		41	Hunton	L		6,938	18		Wilcox	7,690
327		35	Cleveland, Pen	S	*x*	4,796	12		2nd Wilcox	5,998
328		37	Hunton	L		5,543	13		Wilcox	5,885
329			Hunton	L		6,045	34			
330		35	Hunton, Sil-Dev	L		6,004	91		2nd Wilcox	6,610
331		36	Trosper, Pen	S	Por	6,157	11	ML		
332		38	Various, Pen, Ord	S, L	Por					
333		39								
334										
			OSAGE COUNTY							
335		33	Bartlesville, Burgess, Mississippian, Pen, Mis							
336		39	Burgess, Siliceous, Mis, Ord, Cam	S, L		2,500 2,750	25 15			
337		33	Bartlesville, Burgess, Pen	S		1,400 1,450				
338		32	Bartlesville, Burgess, Pen	S						
339		34	Bartlesville, Miss, Pen, Mis	S, L						
340		34	Various, Pen, Mis	S, L						

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
341	Barker	1932	240	x	17,202				11	11
342	Barnsdall	1916	3,620	x	68,076				204	204
343	Barnsdall, South	1921	1,125	x	18,300				81	81
344	Barnsdall, West	1922	1,665	x	97,356				109	109
345	Bartlesville	1904	16,335	x	14,274				64	64
346	Big Bend	1943	160	351,636	246,931					7
347	Big Horse	1927	335	x	3,660				24	24
348	Birch Creek	1920	830	x	8,418				48	48
349	Boston	1904	770	x	111,264				32	32
350	Boston, East			x	5,490				8	8
351	Boston, North	1921	240	x	12,444				9	9
352	Boston, West	1941	160	131,311	25,400				5	5
353	Bowring	1921	160	x	2,928				12	12
354	Branstetter	1928	420	x	16,836				25	25
355	Buell	1922	100	x	8,418				9	9
356	Bulldog	1920	465	x	25,254				31	31
357	Burbank (Osage and Kay)	1920	24,665	214,911,399	3,141,012	2,205			1,688	1,688
358	Burbank, South	Or. 1926 Ext. 1934	4,465	38,646,874	2,506,002	287				222
359	Candy Creek	1920	1,420	x	60,390				55	55
360	Canyon Creek	1923	160	x	63,318				8	8
361	Country Club	1923	515	x	13,908				30	30
362	Dalton	1926	205	x	2,562				4	4
363	Dewey	1904	4,920	x	15,006				108	108
364	Domes	1917	3,740	x	68,808				187	187
365	Edgewood	1921	285	x	732				3	3
366	Elgin, South	1917	1,985	x	13,542				107	107
367	Enfisco	1921	290	x	2,562				5	5
368	Fairfax	1925	220	x	15,006				16	16
369	Falls Dome	1920	380	x	14,274				19	19
370	Flat Rock	1906	7,485	x	229,848				578	578
371	Flesher	1919	320		8,418				5	5
372	Foraker (Redrilled)	1920–42	20	x	2,196				1	1
373	Foraker, South			x	8,418				4	4
374	Forty-five	1916	1,795	x	25,986				107	107
375	Frankfort	1920		x			Abandoned			
376	Gilliland	1919	770	x	12,444				12	12
377	Happy Hollow	1919	540	x	35,502				28	28
378	Hardy	1934	40	x	8,784				2	2
379	Hickory Creek	1914	2,220	x	47,214				156	156
380	Hickory Creek, South	1939	340	x	58,560				46	46
381	Hominy	1916	415	x	17,202				11	11
382	Hominy, East	1918	630	x	15,006				20	20
383	Hominy, South	1940	30	12,711	527				3	3
384	Hominy Falls	1919	1,385	x	25,986				48	48
385	Kasishke	1921	140	x	4,758				17	17
386	Kasishke, South			x	732				2	2
387	Kaw	1922	180	x	27,816				7	7
388	Landon	1919	145	x	732				9	9
389	Lee Dome	1926	80	x	5,490				5	5
390	Madalene	1920	520	x	19,764				38	38
391	Madalene, East	1923	400	x	16,104				33	33
392	Manion	1927	460	x	19,442				31	31
393	Manion, North	1920	910	x	52,338				59	59
394	Myers	1919	260	x			Abandoned			
395	Naval Reserve	1933	3,290	19,426,953	724,985				231	231

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
341		36	Various, Pen, Mis, Ord, Cam							
342		33	Peru, Bartlesville, Mississippian, Arbuckle, Pen, Mis, Cam	S, L		1,100 1,550	x 75			
343		33	Bartlesville, Burgess, Pen	S						
344		34	Bartlesville, Pen	S						
345		33	Various, Pen			650				
346		41	Layton, Pen	S		2,874	16		Layton	2,890
347		35	Bartlesville, Miss, Pen, Mis	S, L						
348		34	Bartlesville, Burgess, Mississippian, Pen, Mis	S, L						
349		37	Various, Pen, Mis, Ord, Cam	S, L		1,500				
350										
351		36	Wilcox, Arbuckle, Ord, Cam							
352		38	Simpson, Ord	S		3,064	15			
353		34	Layton, Peru, Oswego, Mississippian, Pen, Mis	S, L						
354		40	Bartlesville, Burgess, Mississippian, Pen, Mis	S, L						
355		37	Various, Pen, Mis	S, L						
356		34	Various, Pen, Mis	S, L						
357		38	Layton, Burbank, Wilcox, Pen, Ord	S		2,700	60	ML	Granite	4,240
358		38	Burbank, Skinner, Pen	S						
359		33	Bartlesville, Burgess, Pen	S						
360		39	Bartlesville, Burgess, Pen	S						
361		33	Various, Pen, Ord							
362		38	Bartlesville, Burgess, Pen	S						
363		33	Various, Pen	L, S		650				
364		36	Stray, Bartlesville, Mississippian, Pen, Mis	S, L		1,570 1,680 1,880	67 100 45			
365		35	Bartlesville, Burgess, Mississippian, Pen, Mis	S, L						
366		33	Ramsey, Pennsylvanian, Oswego, Pen							
367		36	Stray, Oswego, Miss., Pen, Mis	S, L						
368		38	Oswego, Burbank, Wilcox, Pen, Ord	S	20–25			ML		
369		36	Oswego, Bartlesville, Burgess, Pen							
370		34	Bartlesville, Burgess, Pen	S		1,110 1,345	95 20		Wilcox	1,667
371		35	Bartlesville, Miss., Pen, Mis							
372		33								
373										
374		34	Oswego, Skinner, Bartlesville, Pen							
375		33	Pennsylvanian, Oswego, Mississippian, Pen, Mis	S, L						
376		36	Various, Pen, Mis, Ord, Cam	S, L						
377		36	Oswego, Bartlesville, Burgess, Pen							
378		39	Layton, Pen	S						
379		35	Oswego, Bartlesville, Miss., Pen, Mis	S, L						
380		36	Wayside							
381		34	Various, Pen, Mis, Ord, Cam	S, L		2,625	50	A	Arbuckle	3,206
382		34	Bartlesville, Miss., Hominy, Arbuckle, Pen, Mis, Ord, Cam	S		2,160		A	Arbuckle	2,857
383		37	Oswego, Pen							
384		36	Various, Pen, Mis	S, L						
385		40	Burbank, Pen	S						
386										
387		35	Prue, Skinner, Pen							
388		35	Peru, Oswego, Bartlesville, Pen							
389		36	Oswego, Bartlesville, Burgess, Pen							
390		35	Prue, Oswego, Bartlesville, Pen							
391		35	Bartlesville, Pen	S						
392		38	Layton, Oswego, Bartlesville, Burgess, Pen							
393		38	Bartlesville, Wilcox, Pen, Ord	S						
394		34	Layton, Burgess, Pen							
395		39	Burbank, Pen	S						

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
396	Naval Reserve, South	1938	80	434,614	18,868				6	6
397	Nelagony (Redrilled)	1919–42	80	*x*	9,882				5	5
398	New England	1920	585	*x*	29,646				27	27
399	Ochelata, North	1910	1,560	*x*	35,136				86	86
400	Ohio-Osage	1932	195	*x*					24	24
401	Okesa	1904	1,210	*x*	2,196				10	10
402	Osage City	1904	3,805	*x*	200,568				202	202
403	Osage City, East	1920	805	*x*	41,358				61	61
404	Osage-Hominy	1917	1,625	*x*	242,658				138	138
405	Page	1918	745	*x*	23,058				30	30
406	Pawhuska	1919	505	*x*	23,424				18	18
407	Pawhuska, West	1919	180	*x*	3,660				6	6
408	Pearsonia	1919	220	*x*	72,468				21	21
409	Penn Creek	1922	160	*x*	4,026				2	2
410	Pershing	1918	5,595	*x*	83,082				236	236
411	Pettit	1923	285	*x*	20,496				15	15
412	Pioneer	1920	300	*x*	15,006				21	21
413	Pond Creek	1913	1,295	*x*	15,738				56	56
414	Prue	1926	475	*x*	6,222				11	11
415	Quapaw	1914	3,645	*x*	62,586				197	197
416	Ramona	1911	1,755	*x*	72,102				81	81
417	Skiatook	1911	715	*x*	15,738				27	27
418	Sunset	1919	295	*x*	1,098				10	10
419	Tidal-Osage	1918	1,975	*x*	58,560				106	106
420	Turkey Creek	1917		*x*		Abandoned				
421	Turkey Creek, West	1925	305	*x*		Abandoned				
422	Twin Creek			7,856	5,856				5	5
423	Whitetail	1919	205	*x*	2,196				1	1
424	Wildhorse	1912	4,670	*x*	212,280				389	389
425	Wildhorse, North	1919	360	*x*	12,444				12	12
426	Wildhorse, South	1923	205	*x*	10,248				11	11
427	Wildhorse, West	1940	160	142,061	20,037				4	4
428	Woolaroc	1917	2,525	*x*	35,868				158	158
429	Wynona	1917	3,475	*x*	57,828				154	154
430	Miscellaneous Osage		2,320	*x*	123,628				87	87
431	Aggregate for district of pools marked *x*			339,614,020						
432	Total Osage County			613,747,435	10,669,100					7,951
	SEMINOLE AREA									
433	Adams, *Hughes*	1935	320	2,048,969	216,755				10	10
434	Alabama, *Hughes*	1923	640	*x*	24,888				18	18
435	Buchner, *Hughes*	1924	140	*x*	10,095				1	1
436	Calvin, *Hughes*	1938	80	105,088					3	3
437	Fish, *Hughes*	1934	1,870	19,331,608	586,332		1		139	139
438	Fuhrman, *Hughes*	1925	395	1,810,396	3,297				1	1
439	Gilcrease, *Hughes*	1924	245	422,120		Abandoned 1944				
440	Hawkins, Northwest, *Hughes*	1944	80	9,648	9,648	4				4
441	Holdenville, North, *Hughes*	1926	80	142,701	1,344				1	1
442	Holdenville, West, *Hughes*	1916–30	1,380	5,829,812	181,794		4		104	104
443	Horns Corner, *Hughes*	1943	340	598,625	442,815	13	8			10
444	Horns Corner, North, *Hughes*	1944	100	115,655	115,655	6	6			6
445	Jefferson, *Hughes*	1925		407,219		Abandoned				

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
396			Simpson (Hominy), Ord	S		2,940	110			
397		34								
398		34	Bartlesville, Burgess, Arbuckle, Pen, Ord, Cam							
399		34	Prue, Bartlesville, Pen	S						
400		37	Cleveland, Bartlesville, Pen	S						
401		34	Prue, Bartlesville, Mississippian, Pen, Mis	S, L						
402		37	Burbank, Burgess, Arbuckle, Pen, Ord, Cam	S, L						
403		37	Cleveland, Bartlesville, Pen	S		1,620 2,250	25 30		Mississippian	2,431
404		37	Layton, Oswego, Bartlesville, Burgess, Pen	S, L						
405		33	Various, Pen, Ord, Cam	S, L						
406		35	Bartlesville, Burgess, Burgen, Arbuckle, Ord							
407		36	Bartlesville, Burgess, Burgen, Arbuckle, Pen, Ord, Cam	S, L						
408		36	Layton, Oswego, Burgess, Mississippian, Pen, Mis	S, L						
409		35	Bartlesville, Miss., Pen, Mis	S, L						
410		35	Bartlesville, Cleveland, Pen	S		1,385 2,033	15 30	D		
411		36	Various, Pen, Ord, Cam	S, L			45	A	2nd Wilcox	
412		34	Various, Pen, Ord	S, L						
413		33	Various, Pen, Mis	S, L						
414		36	Prue, Bartlesville, Pen	S						
415		34	Oswego, Skinner, Bartlesville, Pen	S		1,720	60			
416		33	Big Lime, Burgess, Bartlesville, Pen	S, L						
417		34	Bartlesville, Burgess, Mississippian, Pen, Mis	S, L						
418		36	Bartlesville, Hominy, Arbuckle, Pen, Ord	S, L						
419		36	Burgess, Bartlesville, Pen	S						
420		33								
421		33	Pennsylvanian sand, Pen	S						
422										
423			Stray, Miss., Bartlesville, Pen, Mis	S, L						
424		35	Various, Pen, Ord	S, L		3,550				
425		35	Various, Pen, Ord	S, L						
426		35	Various, Pen							
427		39	Arbuckle, Ord, Cam							
428		34	Skinner, Bartlesville, Pen	S						
429		35	Various, Pen, Mis	S, L		1,600				
430		35								
431										
432										
			SEMINOLE AREA							
433		40	Misener, Mis	S	Por		15	A	Wilcox	4,317
434		39	Various, Pen							
435		35	Booch, Cromwell, Pen	S						
436		36	Viola, Ord	L						
437		37	Various, Pen, Ord							
438		37	Gilcrease, Cromwell, Pen	S						
439		39	Gilcrease, Pen	S						
440		36	Booch, Pen	S		2,633	32			
441		40	Cromwell, Pen	S		3,418	19			
442		37	Various, Pen, Ord	S						
443			Cromwell, Pen	S		3,865	18			
444			Cromwell, Pen	S		3,582	8			
445										

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
446	Lamar, *Hughes*	1923		104,160	0	Abandoned				
447	Papoose, *Hughes*	1923	2,815	22,334,257	137,485	379			53	53
448	Spaulding, *Hughes*	1929	80	91,501	4,881				2	2
449	Spaulding, South, *Hughes*	1943	160	54,278	31,262				4	4
450	Spaulding, Southeast, *Hughes*	1939		36,431	10,327				2	2
451	Wetumka, *Hughes*	1923	255	x	16,441				4	4
452	Wetumka, East, *Hughes*	1938	80	172,382	0				3	3
453	Wetumka, South, *Hughes*	1926	100	119,677	2,910				4	4
454	Yeager, *Hughes*	1925	345	1,987,671	29,671				4	4
455	Yeager, North, *Hughes*	1936	100	194,228	18,893				6	6
456	Miscellaneous, *Hughes*		220	232,183	75,524					9
457	Bearden, Northwest, *Okfuskee*	1941	520	510,206	325,614					30
458	Castle, *Okfuskee*	1941	200	193,249	26,060					2
459	Castle, East, *Okfuskee*	1944		3,340	3,340	1	1			1
460	Castle, North, *Okfuskee*	1941	200	74,320	12,697				4	4
461	Castle, South, *Okfuskee*	1941	120	38,656	4,976				3	3
462	Cromwell, East, *Okfuskee*	1940	540	4,859,010	640,866				71	71
463	Dill, *Okfuskee*	1931	1,590	5,332,941	231,886		2		82	82
464	Dill, Northeast, *Okfuskee*	1943	300	278,536	146,601	13	2		13	13
465	Greenlease, *Okfuskee*	1944	40	10,060	10,060	1	1			1
466	Olympic, *Okfuskee*	1934	3,860	12,678,332	379,463	350	1		317	317
467	Rush, *Okfuskee*	1941	300	1,343,111	210,744				10	10
468	Valley Grove, *Okfuskee*	1944		22,283	22,283	3	3		3	3
469	Asher, *Pottawatomie*	1929	430	3,718,667	27,546				5	5
470	Asher, West, *Pottawatomie*	1930	780	7,727,914	74,351				30	30
471	Avoca, *Pottawatomie*	1938	220	1,496,337	66,906				18	18
472	Brooksville, *Pottawatomie*	1942	440	651,987	168,730		3		11	11
473	Brooksville, South, *Pottawatomie*	1943	100	43,784	18,563	1			1	1
474	Burnett, West, *Pottawatomie*	1943	200	36,293	33,990	1				1
475	Centerpoint, *Pottawatomie*	1942	200	198,279	99,353		2			6
476	Centerpoint, South, *Pottawatomie*	1944	40	1,987	1,987	1	1			1
477	Earlsboro, Northwest, *Pottawatomie*	1942	200	264,977	114,222				9	9
478	Earlsboro, West, *Pottawatomie*	1924–29	1,405	3,881,571	227,003				70	70
479	Gray, *Pottawatomie*	1932	320	5,305,346	310,791				23	23
480	Grisso, *Pottawatomie*	1934	210	398,378	13,043				3	3
481	Hotulke, West, *Pottawatomie*	1941–42	1,000	1,648,934	207,045				18	18
482	King, *Pottawatomie*	1939	100	149,339	7,832				3	3
483	King, West, *Pottawatomie*	1939	150	232,771	1,054				1	1
484	Lake Shawnee, *Pottawatomie*	1943	40	35,457	12,360	1			1	1
485	Macomb, *Pottawatomie*	1942	80	60,347	10,825				2	2
486	Macomb, South, *Pottawatomie*	1943	120	134,480	42,680	4			3	3
487	Maud, *Pottawatomie*	1928	1,980	12,563,512	139,664	158			53	53
488	Maud, South, *Pottawatomie*	1941	140	537,091	51,709				8	8
489	Moral, Northeast, *Pottawatomie*	1944	120	32,805	32,805	2	2			2
490	Prague, *Pottawatomie*	1940	220	1,153,672	152,187				17	17
491	Romulus, *Pottawatomie*	1940	450	1,510,260	102,131				17	17
492	Romulus Townsite, *Pottawatomie*	1942	80	47,906	12,199				1	1
493	Sacred Heart, *Pottawatomie*	1939	140	363,264	26,987				8	8
494	Shawnee, *Pottawatomie*	1934	700	3,567,642	201,401				48	48
495	Shawnee, East, *Pottawatomie*	1937	40	65,567	0	Abandoned				
496	Shawnee, North, *Pottawatomie*	1937	160	648,598	154,098 }		3			6
497	Shawnee, Northeast, *Pottawatomie*	1942		493,540	274,053 }					4
498	Shawnee, South, *Pottawatomie*	1943	80	49,088	32,265				2	2
499	Shawnee, Southwest, *Pottawatomie*	1943	40	5,382	3,295	1			1	1
500	St. Louis, *Pottawatomie*	1927	19,905	165,641,198	2,590,548	1,226	1		675	675
501	St. Louis, East, *Pottawatomie*	1941	110	231,726	18,958				8	8
502	St. Louis, North, *Pottawatomie*	1941	1,000	1,127,671	64,416				32	32
503	Tecumseh, *Pottawatomie*	1937	40	182,206	10,132				1	1
504	Tecumseh, East, *Pottawatomie*	1941	280	446,396	14,750				7	7

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
446		39								
447		36	Calvin, Gilcrease, Cromwell, Pen	S	Por		10	A	Wilcox	
448		35	Booch, Pen	S						
449		33	Booch, Pen	S		2,635	23			
450			Booch, Pen	S		2,648	22			
451		38	Various, Pen, Sil-Dev	S, L						
452		44	Hunton, 2nd Wilcox, Sil-Dev, Ord	S						
453		39	Gilcrease, Cromwell, Pen	S						
454		39	Various, Pen, Sil-Dev, Ord	S, L						
455		37	Cromwell, Hunton, 2nd Wilcox, Pen, Sil-Dev, Ord	S, L						
456		35	Booch, Cromwell, Pen	S						
457		35	Booch, Pen	S		2,954	20			
458		43	Booch, Hunton, Pen, Sil-Dev			3,950	10			
459			Cromwell, Pen	S		3,272	23			
460		41	Cromwell, Pen			3,310	13			
461		43	Hunton, Sil-Dev			3,930	12			
462		37	Cromwell, Booch, Hunton, Wilcox, Pen, Sil-Dev, Ord	S						
463		36	Senora, Cromwell, Hunton, Pen, Sil-Dev	S, L	Por					
464		37	Cromwell, Pen	S		3,488	17			
465		43	Hunton, Sil-Dev	L		3,898	x			
466		34	Senora, Cromwell, Pen	S	Por	3,433	x			
467		38	Cromwell, Pen			3,691				
468		23	Dutcher			3,492	8			
469		39	Wanette, Viola, Ord	S, L						
470		43	Wanette			3,450				
471		39	Viola, 2nd Wilcox, Ord	S, L						
472			Hunton, Sil-Dev	L		4,759	28			
473		33	Hunton, Sil-Dev	L		4,854	16		2nd Wilcox	5,481
474			2nd Wilcox, Ord	S		6,241	10		2nd Wilcox	6,251
475			Dolomite, Ord	S		5,593	20			
476		39	Earlsboro, Pen	S		4,914	11			
477			Earlsboro, Pen	S		3,875	20			
478		38	Hunton, Sil-Dev	L						
479		40	Wanette, Hunton, Simpson, Sil-Dev, Ord			2,500	25	A	Wilcox	3,500
480		36	Hunton, Simpson, Sil-Dev, Ord	L					Wilcox	4,860
481		38	Viola, Wilcox, Hunton, Ord, Sil-Dev	S, L						
482		41	Hunton, Viola, Sil-Dev, Ord	L		4,374	42			
483		41	Hunton, Sil-Dev	L		4,281	25			
484		40	Wilcox, Ord	S		5,877	8			
485		34	Hunton, Sil-Dev	L		4,700	75			
486		35	Hunton, Sil-Dev	L		4,664	96		2nd Wilcox	5,451
487		38	Misener, Hunton, Simpson, Mis, Sil-Dev, Ord	S, L	Por	4,130	10	A	Wilcox	4,330
488		41	Simpson, Ord	D		4,320	5			
489			Hunton, Sil-Dev	L		4,540	5			
490		34	Senora, Pen							
491		38	Hunton, Sil-Dev	L						
492			Hunton, Sil-Dev	L		4,880	20			
493		32	Earlsboro, Pen	S		2,862	21			
494		34	Earlsboro, Pen	S	Por			x		
495		31	Wilcox, Ord	S		4,839	5			
496		36	Simpson, Ord			4,853	33			
497		32	Wilcox, Ord	S		4,835	18			
498		37	Sandy Ls			5,185 5,228	6 8		Wilcox	5,234
499		42	Hunton, Sil-Dev	L		5,110	46		Wilcox	5,511
500		38	Various, Pen, Sil-Dev, Ord	S, L	Por			x		
501		39	Wilcox, Ord			4,111	8			
502		37	Hunton, Sil-Dev	L		3,863	16			
503		37	Simpson, Ord	D		5,125	113			
504		35	Viola, Wilcox, Ord			4,582 4,835	38 3			

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Tota
505	Tecumseh Lake, *Pottawatomie*	1941	150	1,167,057	87,393				9	9
506	Wanette, *Pottawatomie*	1943	40	77,526	59,515				1	1
507	Wanette, West, *Pottawatomie*	1943	10	8,334	5,264				1	1
508	Miscellaneous, *Pottawatomie*		150	58,723	2,936				3	3
509	Allen (Deep), *Seminole*	1927	3,400	55,116,822	1,186,997	474			289	289
510	Bethel, *Seminole*	1925	620	1,977,270	49,114				35	35
511	Bethel, North, *Seminole*	1936	300	4,501,375	210,088				24	24
512	Bethel, Northeast, *Seminole*	1941	20	23,371	12,198				3	3
513	Bethel, West, *Seminole*	1941	150	407,172	70,654				5	5
514	Bowlegs, *Seminole*	1926	4,000	124,249,701	1,517,201	364			199	199
515	Carr City, *Seminole*	1927	1,885	32,604,173	553,221	122			71	71
516	Cheyarha, *Seminole*	1944	720	167,914	167,914	15	15			15
517	Cromwell, *Seminole*	1923	5,465	59,397,893	815,082	503			224	224
518	Cromwell, South, *Seminole*	1937	100	611,765	40,159					4
519	Dill, South, *Seminole*	1941	100	199,043	25,597				4	4
520	Dora, *Seminole*	1935	1,110	5,440,338	190,317				102	102
521	Earlsboro, *Seminole*	1926–42	5,235	128,475,061	887,090	500	1		157	157
522	Earlsboro, East, *Seminole*	1929	2,105	40,164,950	444,180	192			69	69
523	Earlsboro, North, *Seminole*	1936	460	7,858,277	662,275					35
524	Earlsboro, South, *Seminole*	1930	430	9,510,546	167,604	39			21	21
525	Fish, West, *Seminole*	1941	30	25,805	5,208				1	1
526	Grayson, *Seminole*	1935	530	2,334,019	118,864				28	28
527	Grayson, North, *Seminole*	1942	10	4,739					1	1
528	Haney, East, *Seminole*	1927		395,355	13,542				2	2
529	Hazel, *Seminole*	1938	330	601,779	62,147				18	18
530	Jackson, *Seminole*	1925	720	825,394	34,594				12	12
531	Keokuk, *Seminole*	1933	2,585	13,840,395	559,191	108			82	82
532	Konawa, *Seminole*	1929	1,695	16,144,064	305,453	133			87	87
533	Konawa, East, *Seminole*	1936	225	231,680	9,185				5	5
534	Konawa, South, *Seminole*	1938	560	1,467,634	85,248				38	38
535	Konawa, West, *Seminole*	1938	220	774,491	66,936				15	15
536	Little River, *Seminole*	1927	4,090	116,576,407	1,431,803	602			200	200
537	Little River, East, *Seminole*	1928	910	17,209,538	144,419				61	61
538	Little River, North, *Seminole*	1941	220	521,731	99,186				5	5
539	Little River, Southeast, *Seminole*	1940	40	40,881	8,460				3	3
540	Little River, West, *Seminole*	1938	220	1,082,973	60,394				12	12
541	Mission, *Seminole*	1928	1,570	26,468,773	292,711	122			45	45
542	Rosanna, *Seminole*	1924	505	x	57,643				20	20
543	Sancho, *Seminole*	1929	120	369,681	10,382				6	6
544	Sasakwa, *Seminole*	1927	1,145	11,686,730	246,851				58	58
545	Sasakwa, East, *Seminole*	1937	40	63,162	4,801				2	2
546	Sasakwa Townsite, *Seminole*	1933	175	2,570,298	69,019				8	8
547	Searight, *Seminole*	1926	2,110	35,165,289	269,921	145			55	55
548	Searight, East, *Seminole*	1939	80	194,576	7,368				4	4
549	Searight, North, *Seminole*	1934	451	4,007,300	151,170	19			12	12
550	Seminole City, *Seminole*	1926	4,635	134,269,970	1,621,783	411			185	185
551	Seminole, East, *Seminole*	1926	1,680	9,274,718	221,547	134			82	82
552	Seminole, North, *Seminole*	1940	100	126,026	19,774				7	7
553	Seminole, West, *Seminole*	1935	500	14,642,853	377,927	43			34	34
554	Swan, *Seminole*	1938	10	19,064	1,927				1	1
555	Sylvian, *Seminole*	1941–42	300	244,649	103,539				7	7
556	Sylvian, Northeast, *Seminole*	1942	80	39,334	8,817				2	2
557	Transco, *Seminole*	1926	40	104,143		Abandoned				
558	Transco, West, *Seminole*	1941		5,823	1,847				1	1
559	Traugh (Deep), *Seminole*	1937	140	1,021,628	36,234				9	9
560	Traugh (Shallow), *Seminole*	1937	270	1,047,414	60,500				24	24
561	Tyrola, *Seminole*	1937	100	105,348	8,470				3	3

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
505		38	1st Wilcox, Ord			5,234	10			
506		38	Viola, Ord	L		4,140			2nd Wilcox	4,695
507			Dolomite			5,118	12		Wilcox	5,304
508		36	Earlsboro, Pen	S						
509		36	Various, Mis, Sil-Dev, Ord	S, L		2,500				
510		36	Booch, Gilcrease, Cromwell, Pen	S				ML		
511		40	Cromwell, Pen	S	Por		20	A	Cromwell	
512		34	Cromwell, Pen							
513		38	Cromwell, Pen			3,450				
514		40	Various, Pen, Sil-Dev, Ord	S, L	Por		30	A		
515		40	Hunton, Wilcox, Misener, Mis, Sil-Dev, Ord	S, L	Por	4,180		A	Wilcox	4,210
516		40	Booch, Pen	S		3,429	12		Cromwell	3,563
517		37	Various, Pen, Ord	S	Por			AF	Wilcox	4,226
518		37	Wapanucka-Cromwell, Wilcox, Pen, Ord	S		4,176	13			
519		42	Hunton, Sil-Dev			4,128	22			
520		35	Boggy, Calvin, Pen	S		2,947				
521		38	Earlsboro, Hunton, Wilcox, Simpson Dolomite, Pen, Sil-Dev, Ord	S, L						
522		39	Calvin, Hunton, Wilcox, Pen, Sil-Dev, Ord	S, L						
523		41	Hunton, Wilcox, Sil-Dev, Ord	S, L				A	Wilcox	4,680
524		39	Calvin, Hunton, Wilcox, Pen, Sil-Dev, Ord	S, L	Por	4,200	25	A	Wilcox	4,225
525		38	Booch, Pen	S		3,168	24			
526		40	Simpson, Ord	D	x	4,030	20	x	x	x
527			Hunton, Sil-Dev	L		4,160	10			
528										
529		36	Thurman, Boggy, Pen	S		2,991	12	x		
530		38	Booch, Pen	S						
531		40	Misener, Hunton, Wilcox, Mis, Sil-Dev, Ord	S, L	x			x	Wilcox	4,483
532		36	Earlsboro, Cromwell, Simpson, Pen, Ord	S						
533		39	Earlsboro, Pen	S						
534		37	Hunton, Viola, Wilcox, Sil-Dev, Ord	S, L						
535		36	Boggy, Calvin, Pen	S		2,697	17			
536		38	Various, Pen, Ord	S	Por			x		
537		36	Various, Pen, Ord	S	x			x		
538		39	Hunton, Wilcox, Dolomite, Sil-Dev, Ord			4,282	7			
539		38	Senora, Pen							
540		39	Wilcox, Ord	S		4,378	2			
541		39	Hunton, Wilcox, Sil-Dev, Ord	S, L						
542		38	Booch, Pen	S		3,034	20			
543		37	Gilcrease, Cromwell, Pen	S						
544		36	Various, Pen, Ord	S, L		2,793				
545			Senora	S		1,265	10		Gilcrease	2,610
546		37	Wilcox, Ord	S	Por	4,047	3	x		
547		38	Hunton, Wilcox, Sil-Dev, Ord	S, L	Por	4,120		x		
548		39	Cromwell, Pen	S		3,775	16	x		
549		32	Wilcox, Ord	S	x	4,596		x		
550		39	Various, Pen, Mis, Sil-Dev, Ord	S, L	Por			x	x	
551		38	Cromwell, Hunton, Wilcox, Pen, Sil-Dev	S, L						
552		31	Senora, Pen							
553		42	Calvin, Wilcox, Pen, Ord	S	Por	4,085	30	A	Wilcox	4,150
554		36	Thurman	S		2,671	20			
555		40	1st Wilcox, Cromwell, Ord, Pen			4,366	18			
556			Cromwell, Pen	S		3,652	10			
557		36	Calvin, Senora, Pen			2,159	15			
558										
559		36	Simpson, Wilcox, Ord	S						
560		33	Earlsboro, Pen	S		2,347	13			
561		37	Hunton, Sil-Dev	L		3,317	x			

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
562	Tyrola, East, *Seminole*	1943	80	5,648	390	1			1	1
563	Wetley, *Seminole*	1927	675	602,672	29,738				17	17
564	Wewoka, *Seminole*	1923	2,015	34,953,862	298,060				80	80
565	Wewoka, East, *Seminole*	1927	365	1,605,316	27,787				8	8
566	Wewoka Lake, *Seminole*	1943	320	192,695	185,854	15	14			15
567	Wewoka, North, *Seminole*	1940	100	317,660	35,587				5	5
568	Wewoka, Northeast, *Seminole*	1941	560	1,137,089	227,220				27	27
569	Wewoka townsite, *Seminole*	1924	345	6,327,913	102,114				21	21
570	Wofford, *Seminole*	1935	60	688,960	9,299				3	3
571	Miscellaneous, *Seminole*		190	156,827	35,216					13
572	Aggregate for district of pools marked *x*			4,121,251						
573	Total Seminole Area			1,231,777,893	23,937,411					4,617
	SOUTHEASTERN OKLAHOMA									
574	Ardmore, *Carter*	1942	40	155,319	69,235					2
575	Brock, *Carter*	1922	765	3,787,192	78,598				127	127
576	Caddo, *Carter*	1939	40	58,308	7,545				1	1
577	Caddo (Deep), *Carter*	1942	120	149,583	525	Abandoned				
578	Caddo, North, *Carter*	1944		13,979	13,979		1			1
579	Centrahoma, *Coal*	1937	80	146,818	20,067		3		3	3
580	Clarita, *Coal*	1937	40	91,421	6,910				3	3
581	Miscellaneous, *Coal*	1940		1,413					1	1
582	Allred (Lewis), *Garvin*	1944	60	17,505	17,505		3			3
583	McGee, *Garvin*	1944			In Progress of Completion					
584	Pauls Valley, *Garvin*	1942	1,700	6,726,486	3,933,672	88	33			87
585	Pauls Valley, East, *Garvin*	1944	1,760	241,585	241,585		31			31
586	Pauls Valley, West, *Garvin*	1944	20	1,142	1,142		1		1	1
587	Miscellaneous, *Garvin*	1936		15,364					1	1
588	Citra, *Hughes*	1937	20	6,130		Abandoned				
589	Marietta, North, *Love*	1937		4,617		Abandoned				
590	Overbrook, *Love*	1943	10	3,361	2,041	1			1	1
591	Byars, *McClain*	1939	280	691,960	88,870		1		10	10
592	Aylesworth, *Marshall*	1942	160	140,521	85,747	5	2			5
593	Cumberland, *Marshall*	1940	2,170	13,710,381	4,420,208	113	27			110
594	Enos, *Marshall*	1933	265	184,397	9,882				23	23
595	Isom Springs, *Marshall*	1931	380	258,813	27,816		1		65	65
596	Kingston, *Marshall*	1932	115	18,718	486				9	9
597	Madill, *Marshall*	1925	275	1,141,946	7,686				63	63
598	Miscellaneous, *Marshall*	1932		1,343					1	1
599	Ada, East, *Pontotoc*	1928	325	324,050	21,960				10	10
600	Allen, Shallow, *Pontotoc*	1913	2,530	9,025,610	90,402		4		178	178
601	Bebee, *Pontotoc*	1923	2,530	14,828,814	800,808		1		212	212
602	Bebee, East, *Pontotoc*	1930	215	511,742	38,143				20	20
603	Conservation, *Pontotoc*	1927	285	569,839	18,666				13	13
604	Fitts, *Pontotoc*	1933	5,955	100,547,506	2,061,912	989			596	596
605	Fitts, East, *Pontotoc*	1944		404	404		1		1	1
606	Fitts, North, *Pontotoc*	1934	150	607,336	21,164				15	15
607	Fitts, South, *Pontotoc*	1937	205	588,839	45,425				22	22
608	Fitts, West, *Pontotoc*	1937	175	555,416	38,456				11	11
609	Francis, *Pontotoc*	1918	60	*x*		Abandoned				
610	Francis, West, *Pontotoc*	1917	60	*x*	5,856				8	8
611	Jesse, *Pontotoc*	1935	1,235	6,797,676	562,390					56
612	Oakman, *Pontotoc*	1935	140	30,083	333		1		1	1
613	Roper, *Pontotoc*	1942	190	161,970	51,194				6	6
614	Steedman, *Pontotoc*	1920	50	23,310					1	1
615	Steedman, North, *Pontotoc*	1928	305	1,876,661	69,174				13	13
616	Miscellaneous, *Pontotoc*		20	7,344						
617	Aggregate for district of pools marked *x*			245,895						
618	Total Southeastern Oklahoma			164,270,797	12,859,786					1,711

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
562		26	Senora	S		1,745	15			2,809
563		35	Hunton, Sil-Dev	L		2,420	165			
564		37	Cromwell, Hunton, Wilcox, Pen, Sil-Dev, Ord	S, L	Por					
565		38	Hunton, Wilcox, Sil-Dev, Ord	S, L		4,214				
566			Booch			3,334	10			
567		41	Wilcox, Ord							
568		38	Misener, Hunton, Mis, Sil-Dev			3,940	55			
569		38	Various, Pen, Sil-Dev, Ord							
570		40	Boggy, Wilcox, Pen, Ord	S						
571		37	Senora, Calvin, Hunton, Pen, Sil-Dev	S, L						
572										
573										
			SOUTHEASTERN OKLAHOMA							
574			Springer, Pen	S		3,302	40			
575		32	Ordovician, Arbuckle, Ord, Cam	S	Por			AF	Ord Lime	3,000
576		35	Woodford, Mis	S		4,170	154			
577			Bromide, Ord	S		5,412	15			
578		40				5,346				
579		38	McAlester, Viola, Pen, Ord	S, L		5,970	265			
580		39	Atoka	S		790	46			
581		48	Cromwell, Pen			1,835	65			
582		27				1,897			Simpson Bromide	1,919
583			Pennsylvanian			2,492	6		Simpson Bromide	3,542
584		42	Bromide, Ord	S		3,950	50			
585		33	Bromide, Ord			2,960			McLish	3,250
586		40				4,463				
587										
588		34	Bromide, McLish, Ord	S		5,755				
589		34								
590		39	Springer	S		3,160	40			
591		37	Layton, Viola, Pen, Ord	L		3,485	138			
592			Tulip Creek, Ord	S		3,110	10			
593		37	Bromide, McLish, Ord							
594		25	Preston, Arbuckle, Ord, Cam							
595		26	Stray sand	S		537	3			
596		26	Cretaceous, Trinity							
597		40	Bilbo, Arbuckle, Ord, Cam	S		402				
598										
599		27	Boggy, Senora, Pen	S		1,790	5			
600		30	Allen							
601		36	Boggy, Hunton, Viola, Pen, Sil-Dev, Ord							
602		35	Senora, Hunton, Viola, Simpson, Pen, Sil-Dev, Ord	S, L						
603		30	Boggy, Hunton, Pen, Sil-Dev						Wilcox	3,062
604		39	Various, Pen, Sil-Dev, Ord	S, L						
605									Hunton	4,218
606		32	McAlester, Gilcrease, Pen	S		1,267				
607		35	Gilcrease, Hunton, Viola, Pen, Sil-Dev, Ord	S, L						
608		39	Cromwell, Pen	S		3,021	89			
609		26	Allen, Senora, Pen			1,200	800			
610		27	Allen, Senora, Pen							
611		40	Hunton, McLish, Sil-Dev, Ord	L, S						
612		23	Boggy, Pen	S		1,160	9			
613			Viola, Ord	L		2,531	41			
614		31	Boggy, Pen							
615		31	Boggy, Pen							
616		36	Hunton, Sil-Dev	L						
617										
618										

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Oil Wells Producing[g] Dec. 1944[i]: Artificial Lift	Oil Wells Producing[g] Dec. 1944[i]: Total
	SOUTHWESTERN OKLAHOMA									
619	Sayre, *Beckham*	1923		304,519		Abandoned				
620	Apache, *Caddo*	1941	1,000	6,511,721	2,284,728	29				28
621	Binger, *Caddo*	1934	80	86,749		1			1	1
622	Cement, *Caddo*	1917	4,505	32,906,751	4,172,769	532	31			394
623	Miscellaneous, *Caddo*			6,565		Abandoned				
624	Ed Cox, *Carter*	1925	770	957,145	71,736		9		44	44
625	Fox, *Carter*	1917–35	1,100	15,390,579	237,900				91	91
626	Graham, *Carter*	1917	2,990	27,377,310	308,538				251	251
627	Healdton, *Carter*	1913	7,550	198,495,177	2,506,183	2,370	5		1,873	1,873
628	Hewitt, *Carter*	1919	4,530	100,243,198	2,037,392	1,106	3		894	894
629	Lone Grove, Southwest, *Carter*	1944	700	198,771	198,771	15	15			15
630	Sholem-Alechem, *Carter*	1923	4,760	40,310,360	798,487	401			301	301
631	Tatums, *Carter*	1927	2,660	17,939,862	590,648	248	1		210	210
632	Tussy, *Carter*	1933	1,340	7,378,512	1,071,009		20			130
633	Wheeler, *Carter*	1916	755	*x*	20,130				38	38
634	Wildcat Jim, *Carter*	1914	1,235	*x*	498,858		3		88	88
635	Miscellaneous, *Carter*			2,437	180				4	4
636	Ft. Sill Reservation, *Comanche*	1943	160	105,011	58,987	25	9		17	17
637	Hansbury, *Comanche*	1920	280	*x*	4,758		1		5	5
638	Lawton, *Comanche*	1915	960	*x*	4,392				94	94
639	Walters, *Cotton*	1917	3,790	26,219,298	243,024		1		210	210
640	Hoover, Northwest, *Garvin*	1944	110	101,959	101,959	13	13			13
641	Robberson, *Garvin*	1921	2,410	16,050,878	273,679	328			166	166
642	Knox, *Grady*	1924	1,990	16,483,902	442,026	272			177	177
643	Miscellaneous, *Grady*	1923	40	*x*	5,124				1	1
644	Altus, *Jackson*	1934	1,740	2,106,543	159,747		3		117	117
645	Tipton, *Jackson*	1935	880	2,077,903	105,037				57	57
646	Oscar, *Jefferson*	1924	685	11,378,878	362,340		1		191	191
647	Seay, *Jefferson*	1924	325	578,873	19,398		2		44	44
648	Spring, *Jefferson*	1924	265	*x*	118,950				38	38
649	Hobart, *Kiowa*	1939	500	1,464,778	44,047				23	23
650	Stockton, *Love*	1937	40	71,756	7,294					1
651	Goldsby, *McClain*	1944	160	10,369	10,369	1	1			1
652	Washington, *McClain*	1944	340	29,724	29,724	1	1			1
653	Comanche, *Stephens*	1918	925	10,827,604	132,858		4		141	141
654	Cruce, *Stephens*	1926	100	*x*	6,222				3	3
655	Doyle, *Stephens*	1921–37	315	*x*	366,732		8			48
656	Doyle, West, *Stephens*	1939	100	180,942	25,690					3
657	Duncan, North, *Stephens*	1920	1,260	4,600,594	117,486				80	80
658	Duncan, West, *Stephens*	1919	910	6,461,880	357,948		4			85
659	Empire, *Stephens*	1920	2,630	*x*	456,768		13		243	243
660	Loco, *Stephens*	1915	575	1,738,248	105,408		51		91	91
661	Loco, West, *Stephens*	1941	750	439,438	250,256				57	57
662	Marlow, West, *Stephens*			42,920	5,500				4	4
663	Milroy, Deep, *Stephens*	1937–39	80	718,050	76,128					1
664	Milroy, Shallow, *Stephens*	1916	800	3,652,422	93,696				141	141
665	Palacine, *Stephens*	1929	120	204,817	9,882				3	3
666	Rainola, *Stephens*	1921	150	*x*	23,424				18	18
667	Velma, Shallow, *Stephens*	1917	3,710	7,591,265	682,590		60		718	718
668	Velma, Deep, *Stephens*	1941	440	368,933	116,022 }					[illegible]
669	Velma, North, *Stephens*	1942		20,596	6,874 }				1	1
670	Woolsey, *Stephens*	1922	170	*x*	25,986		2		18	18
671	Woolsey, South, *Stephens*	1942	60	122,572	36,516				7	7
672	Miscellaneous, *Stephens*		140	59,878	35,868				12	12
673	Frederick, *Tillman*	1937	100	43,464	6,367				3	3
674	Frederick, West, *Tillman*	1937–39	300	3,327,470	232,926				26	26
675	Red River Bed, *Tillman*	1920	500	*x*	92,232				80	80
676	Sentinal, West, *Washita*	1943	200	89,487	88,265	5	4			3
677	Aggregate for district of pools marked *x*			43,590,532						
678	Total Southwestern Oklahoma			608,870,640	20,139,828					7,307
679	Total Oklahoma			5,312,925,041	124,394,800					52,438

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.	Character of Oil[i]	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
SOUTHWESTERN OKLAHOMA										
619		34	Deese, Pen	S	Por					
620		40	Simpson, Ord			3,395	35			
621		38	Deese, Pen							
622		34	Various, Per, Pen	S		1,900				
623		40	Miscellaneous Caddo							
624		22	Pontotoc, Deese, Pen			1,250	30			
625		32	Fox sand, Simpson, Oil Creek, Pen, Ord	S		2,200		A		
626		31	Deese, Pen	S	28–30			A	Dornicks Hills	5,180
627		31	Various, Pen, Ord	S, L		920		AF	Arbuckle	x
628		34	Hewitt, Viola, Pen, Ord	S	15–20	920		AF	Arbuckle	x
629		36	Deese, Pen	S		2,760	26			
630		29	Hoxbar, Deese, Pen	S	30	1,890		A		
631		27	Deese, Arbuckle, Pen, Ord	S	30		60			
632		23	Deese, Pen	S	Por			A		
633		20	Pontotoc, Pen	S	x			A		
634		24	Pontotoc, Deese, Pen			1,552				
635		20								
636		36	Permian, Per	S		790	153			
637		38	Various, Pen	Gw, S		1,640				
638		30								
639		34	Cisco, Hoxbar			2,100				
640		38	Various			1,107			Pennsylvanian	1,120
641		23	Pontotoc, Simpson, Pen, Ord	S, L	x	1,200		A		
642		35	Pontotoc, Pen	S	15–20	1,700	15	AF		8,963
643		36	Pontotoc, Pen							
644		41	Granite Wash, Pen	Gw	Por		30	D		
645		40	Canyon, Arbuckle, Ord	L						
646		33	Glenn, Pen	S		1,180	25			
647		35	Cisco, Hoxbar			1,100				
648		35	Hoxbar			2,095	6			
649		35	Pontotoc, Conglomerate, Pen	L		1,091	16			
650		36	Unidentified	S		6,893	34			
651		40	2nd Wilcox, Ord	S		8,190	32		Simpson Bromide	8,222
652		39	2nd Wilcox, Ord	S		10,625	20		Simpson Bromide	11,209
653		34	Stray, Wilson, Pace	S		1,400				
654		30	Upper Penn, Pen	S		800				
655		30	Permian, Hoxbar, Deese			1,100				
656		42	Deese, Pen	S		5,578	36			
657		36	Thomas			1,700				
658		33	Brown, Blaydes			1,700				
659		39	Various			1,600				
660		23	Pontotoc, Deese, Pen	S		850				
661			Sandy Lime			1,113				
662										
663		42	Hunton, Oil Creek, Sil-Dev			7,554	71			
664		26	Pontotoc, Pen							
665		36	Penn., Arbuckle, Pen, Ord							
666		36	Smith, Brown, Pen							
667		26								
668										
669			Bromide, Ord	S		7,000	100			
670		32	Permian, Glenn, Per, Pen							
671			Arbuckle, Cam, Ord	L		1,783	22			
672		36	Deese, Pen	S						
673		39	Canyon, Strawn, Ord	L, S		3,081				
674		37				4,215	3			
675		39	Cisco			1,540	19			
676			Granite Wash, Pen	Gw		5,444	33			9,971
677										
678										
679										

TABLE 2.—*Important Wildcats Drilled and Completed in Oklahoma in 1944*

County	Sec.	Twp.	Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fraction of Inch	Pressure, Lb. per Sq. In.: Casing	Pressure, Lb. per Sq. In.: Tubing	Remarks
NORTHERN OKLAHOMA													
Logan	36	18 N	4 W	4,855	Permian	Layton	Kerlyn Oil Co.	136				2″	Layton sand discovery
Noble	36	24 N	1 W	4,511	Permian	2nd Wilcox	Mid-Continent						Dry hole
Noble	22	24 N	2 W	5,100	Permian	Arbuckle	Fox & Fox						Dry hole
Ellis	27	24 N	26 W	9,305	Late Tertiary	Chester	Gulf et al.						Dry hole
Kay	31	25 N	2 W	5,267	Permian	Arbuckle	Amerada						Dry hole
Cimarron	28	3 N	6 ECM	7,032	Late Tertiary	Pre-Cambrian	Stanolind						Dry hole
Texas	28	4 N	10 ECM	5,888	Late Tertiary	Arbuckle	Gulf						Dry hole
Cleveland	26	10 N	3 W	8,902	Permian	2nd Wilcox	Mid-Continent	332		14/64		1,000	Wilcox discovery
Cleveland	26	10 N	3 W	9,219	Permian	2nd Wilcox	Mid-Continent	280		12/64	1,300	1,000	Bartlesville sand discovery
Cleveland	32	10 N	3 W	8,875	Permian	2nd Wilcox	Mid-Continent	625			750	250	Hunton discovery
Oklahoma	19	13 N	4 W	7,667	Permian	Sylvan	Denver P. & R. Co.						Dry hole
Oklahoma	11	14 N	1 W	5,971	Permian	2nd Wilcox	Jordan Petr. Co.	52 per hr.		3/4	SIP 1,330		NE. Arcadia discovery
Oklahoma	12	14 N	3 W	6,510	Permian	2nd Wilcox	Phillips Petr. Co.	16					Bartlesville discovery
Canadian	23	14 N	5 W	7,400	Permian	Sylvan	Gutowsky						Dry hole
Logan	15	16 N	4 W	5,206	Permian	Layton sand	Davon						Dry hole
Logan	22	17 N	3 W	6,330	Quaternary	2nd Wilcox	Gulf Oil Co.	81 through casing					Layton sand discovery
Logan	12	17 N	4 W	4,967	Permian	Layton sand	Eason Oil Co.	90 distillate	3 M		SIP 1,710	1 hr.	Layton sand discovery
Logan	31	18 N	3 W	6,270	Permian	2nd Wilcox	Atlantic	102					2nd Wilcox discovery
Seminole	28	10 N	7 E	3,563	Pennsylvania	Cromwell	Gulf Oil Co.	183				2″	Booch discovery
Lincoln	28	14 N	3 E	5,250	Permian	2nd Wilcox	Sinclair	138				2½″	Cleveland sand discovery
Payne	16	19 N	4 E	4,041	Permian	2nd Wilcox	Stanolind	114		3/8	620	40	2nd Wilcox discovery
Payne	10	19 N	5 E	3,566	Pennsylvanian	2nd Wilcox	Sun Oil Co.	30		½	300	100	2nd Wilcox discovery
Pawnee	33	21 N	6 E	3,338	Pennsylvanian	2nd Wilcox	Sun Oil Co.	26					Prue sand discovery
Creek	6	14 N	8 E	3,922	Pennsylvanian	2nd Wilcox	Nadel & Gussman	25					Prue discovery
Lincoln	27	13 N	3 E	5,506	Permian	2nd Wilcox	Stanolind						Dry hole
Lincoln	15	14 N	3 E	4,043	Permian	Prue	Sorrels	25		3/4	175		Prue discovery
Creek	36	14 N	7 E	4,120	Pennsylvanian (Pawhuska)	2nd Wilcox	Skelly						Dry hole
SOUTHERN OKLAHOMA													
Garvin	14	1 N	1 W	1,120	Pennsylvanian	Pennsylvanian	Helmerich-Payne	140		¼		2″	
Garvin	5	2 N	1 W	6,158	Red Beds	Simp. Brom.	Sobio Producing Co.						Dry hole
Stephens	16	2 N	7 W	10,006	Red Beds	Hoxbar	Gulf Oil Co.						Dry hole
Stephens	16	2 N	8 W	6,396	Red Beds	Pennsylvanian	The Texas Co.		9¼ M		SIP 1,940	2″	
Grady	8	5 N	8 W	10,404	Red Beds	Deese	Skelly Oil Co.						Dry hole

County	Sec.	Twp.	Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fraction of Inch	Pressure, Lb. per Sq. In.: Casing	Pressure, Lb. per Sq. In.: Tubing	Remarks
SOUTHERN OKLAHOMA													
McClain..........	30	8 N	2 W	8,222	Red Beds	Simp. Brom.	Carter Oil Co.	322		¼		2″	
McClain..........	4	7 N	3 W	11,209	Red Beds	Simp. Brom.	Carter Oil Co.	324		½		2″	
McClain..........	13	8 N	4 W	10,536	Red Beds	Simp. Brom.	Carter Oil Co.						Dry hole
Washita..........	8	8 N	20 W	9,771	Red Beds	Arbuckle Ls.	Gulf Oil Corp.	345		½		2″	Prod. from Granite wash
McClain..........	28	8 N	3 W	10,884	Red Beds	Simp. Brom.	Carter Oil Co.						Dry hole
Beckham..........	25	9 N	22 W	8,220	Red Beds	Woodford	Northern Ordnance						Dry hole
Custer............	18	12 N	19 W	7,150	Red Beds	Deese	Fox & Fox						Dry hole
Carter............	31	2 S	2 W	8,247	Red Beds	McLish	Continental Oil Co.	365		1	CP 650	TP 50	Prod. from Hunton
Love..............	29	7 S	3 W	4,832	Red Beds	Arbuckle	Gulf Oil Corp.						Dry hole
Garvin............	13	3 N	1 E	3,250	Red Beds	McLish	Ramsey Petr. Co.	35				2″	Penn. sand well
Garvin............	20	3 N	3 E	1,919	Red Beds	Simp. Brom.	Sinclair-Prairie	112				2″	
Garvin............	4	4 N	3 E	3,542	Red Beds	Simp. Brom.	Skelly Oil & Tide Water	50		¼		2″	
Atoka............	19	1 S	12 E	7,020	Red Beds	Atoka	Northern Ordnance						Dry hole
Carter............	6	3 S	2 E	10,017	Springer	McLish, (Arbuckle)	The Pure Oil Co.						Dry hole
Love..............	35	8 S	2 E	6,429	Red Beds	Arbuckle	Sinclair-Prairie						Dry hole
Marshall..........	19	8 S	6 E	7,901	Springer	Springer	The Texas Co.						Dry hole
Hughes...........	21	5 N	11 E	5,576	Red Beds	Cromwell	Stanolind-Amerada		44 M			2″—RP 1,600	
Grady............	16	5 N	8 W	6,270	Red Beds	Deese	Okla. Natural Gas Co.		10 M			2″—SIP 225	

In Chickasha, Oklahoma's only other gas field worthy of note, only one well was completed during the year, which had an initial production of 7,000,000 cu. ft. Withdrawals from the pool increased from 20,070,000 M cu. ft. in 1943 to 24,003,000 M cu. ft. in 1944.

With the entry of carbon-black plants into the state, because of an ever increasing demand for carbon black for the rubber industry, together with the actual and proposed gas pipe lines carrying gas to the east, gas production is fast becoming a very important phase of the industry in Oklahoma.

Important Development in Pools Discovered Prior to 1944

West Edmond.—By far the greatest concentration of development was at West Edmond, discovery being in sec. 32, 14N. 4W., Oklahoma County, in April 1943, the greatest wartime discovery in the United States. At the close of the year, the proven area extended 12 miles north and south and averaged about 2½ miles in width. Should north and south outpost wells now drilling prove to be commercial, the field's length would be increased to approximately 22 miles. Wells at West Edmond came in with an average initial production close to 2000 bbl. from the Hunton lime, at around 7000 ft., making it the world's deepest Hunton lime production. Production in the main is from the Bois d'Arc member of the Hunton limestone and the lower Chimney Hill of the Hunton and the Bartlesville sand of the Pennsylvanian are also locally productive. The structural conditions affording accumulation at the West Edmond pool are rather unique, particularly for a Hunton limestone pool. Located on a generally west-dipping monocline, accumulation is affected by structural contours closing into a zone of either truncation and/or nondeposition of the Hunton limestone updip. Almost identical structural conditions affect the Bartlesville producing horizon in the Pennsylvanian except that truncation does not affect this horizon. Thus, probably there is a rather typical shore-line accumulation in the westward-plunging beds of the Bartlesville off the west flanks of the Granite (Nemaha) Ridge. At the close of the year the field continued to be the nation's most active from a development standpoint, there being 131 rotary rigs in operation closely approaching 10 per cent of the nation's rotary equipment. Rigs and locations numbered 51 during the last week of the year, for a total of 182 active operations.

Other pools in Oklahoma recording the greatest number of oil-well completions include: Cumberland, with 27 completions; Loco area, 51; Pauls Valley, 30; Velma, 56; Crescent, 27; Southeast Stroud, 43; and Tussy, 20.

Cumberland.—At Cumberland, the number of producing wells increased from 87 to 110 at the close of 1944. Production, having an over-all average of 37° gravity, is from the Bromide, McLish, and Oil Creek sands. Although the pool had an increasing number of producing wells during the year, the production was held to a constant daily average of approximately 12,100 bbl. for a total of 4,420,000 bbl. and an accumulated production to Jan. 1, 1945, of 13,710,000 bbl. At the close of the year, there were 11 rigs and drilling operations. It might be of interest to point out that this field is within the general area affected by impounded waters of the huge Denison dam. In order to allow the maximum recovery from this crude reservoir, the Federal Government in the past two years has spent several million dollars on a system of dikes and channels to control the "back-up" waters of the Washita River and its tributaries, which otherwise would have inundated much of the Cumberland field.

Loco and West Loco.—In the Loco and West Loco fields of 2 and 3S. 5 and 6W.,

Stephens County, 51 oil wells were completed, bringing to a total of 155 producers in the two fields in December, with a total daily average production of 1071 bbl. The 1944 completed wells average around 1000 ft. in depth with an approximate average initial of 10 bbl. The oil tests from 20° to 23° gravity. Originally discovered in 1915, the Pontotoc and Deese sands have yielded an accumulated total of 2,300,000 bbl. in the two pools, 1,738,000 being credited to the Loco pool and 562,000 bbl. to the West Loco pool, a 1941 discovery.

Pauls Valley.—Because of a relaxation of the 40-acre Federal Well Spacing Order M-68 to permit 20-acre spacing, the Pauls Valley pool, of Garvin County, a 1942 discovery, had 29 oil well completions during 1944, with a total of 87 producing at the close of the year. With 1944 production amounting to 3,934,000 bbl., Pauls Valley had an accumulated production of 6,726,000 bbl. at the end of 1944. Production, testing better than 40° gravity, is from the Bromide and Basal Pennsylvanian zones from around 3900 to 4000 feet.

Velma—Shallow and Deep.—Originally discovered in 1917, the Velma pool (both shallow and deep), in Stephens County, had an accumulated production to Jan. 1, 1945, of 7,960,000 bbl., 7,591,000 bbl. from the shallow (Permian) formation and 369,000 from the deeper horizon that was discovered in 1941.

Shallow production is obtained from sands ranging from 600 to 1000 ft. in depth, with an average initial production of 10 bbl. and a gravity range from 26° to 28°. The deep pay zone was discovered by the Skelly Oil Co. in the C. NE. NE. of sec. 35, 1S. 5W., in December 1941, production being encountered in the Bromide sand from 7142 to 7205 ft. The well initialed 200 bbl. of 41° gravity oil. At the close of the year, 718 shallow wells were producing a daily average of 2129 bbl., and the pool's three deep sand wells were averaging a total of 244 bbl. daily.

Crescent.—Development of the Layton sand area in the Crescent pool of Logan County, encountered at an approximate depth of 4900 ft., accounted for the completion of 27 oil producers and three dry holes. At the close of 1944 there were 75 producing wells averaging 5100 bbl. daily. The 1944 total production of 1,205,600 bbl. brought the pool's accumulated production to 16,170,800 bbl. as of Jan. 1, 1945.

Southeast Stroud.—A 1943 Prue sand discovery, the Southeast Stroud pool of Creek County, received 43 oil-well completions, six gas wells and three dry holes. The pool's 53 oil producers averaged 2477 bbl. daily during December and its total 1944 production of 562,900 bbl. resulted in an accumulated total of 703,700 bbl. The crude tests better than 40° gravity and is encountered at a depth of 2800 to 2900 feet.

Tussy.—Considerable pool development was concentrated in the Tussy pool of Carter County, there being 20 oil wells and three dry holes drilled during the year. Production, testing from 24° to 32° gravity, is obtained from a series of sands from 2500 to 2900 ft. in depth. At the end of 1944 there were 130 wells producing a total daily average of 2640 bbl. During 1944, Tussy produced 1,071,000 bbl., bringing the pool's total production to Jan. 1, 1945, to 7,378,000 barrels.

Production

The downward trend of crude-oil production, which started in 1937 and continued until early in 1944, has not only been arrested but output has been showing a steady increase, and all indications are that this increase will be maintained throughout 1945. During 1944, production in Oklahoma increased from a low of 322,500 bbl. daily in January to 361,400 bbl. daily at the end of the year, for a yearly average of 339,900 bbl. daily compared

with the 1943 average of 332,700, or a gain of 2.2 per cent. At the close of the year, Oklahoma's accumulated production amounted to 5,312,925,000 bbl. The strengthening of Oklahoma's production position is largely the result of development at West Edmond, where, at the end of 1944, there were 314 producing wells averaging a total of 46,500 bbl. daily, making it the state's largest currently producing field. At the beginning (April 1943), wells at West Edmond were allowed to produce at the rate of 300 bbl. daily. On May 1, 1944, this allowed rate of production was reduced to 200 bbl. daily per well and, effective Dec. 1, 1944, production was further reduced to 150 bbl. per day per well. To Jan. 1, 1945, production at West Edmond amounted to 8,205,000 bbl. Oklahoma's second largest producing field at the close of 1944, the prolific Oklahoma City field, was averaging 40,300 bbl. daily from 830 wells. That pool's highest monthly average production during 1944 of 47,500 bbl. daily occurred last February. The accumulated production at Jan. 1, 1945, amounted to 618,911,000 barrels.

Secondary Recovery

No new water-flood projects were started in Oklahoma during 1944; however, there was some expansion to existing projects in the northeastern Oklahoma shallow areas at Glenn pool, Creek County, and in the Burbank pool, Osage County. Development of this nature is handicapped at this time by the scarcity of labor and, it is claimed, by the current price of crude notwithstanding the subsidy payment of 20 to 35¢ per barrel which became effective last August 1.

It might be of interest to point out the results obtained on a water-flooding project that has been in progress since 1937 on a 110-acre lease in sec. 36, 26N. 14E., Washington County. The 110-acre lease was first put on production in 1912. After producing 17 years, it was partially abandoned in 1929 after having produced 241,000 bbl. from 19 wells. In 1937, this lease was acquired by an independent operator who, through the drilling of new wells to Pennsylvanian sands at an average depth of approximately 800 ft. and the injection of water, has, through 1944, developed 85 acres with an additional recovery of 280,000 bbl. from the lease, which is currently producing 130 bbl. daily from 21 new wells drilled.

Another area where secondary recovery is proving highly successful is in the Glenn pool of eastern Creek County, which was started in 1942. At the present time it is principally a gas-repressuring system, although some compressed air is being injected into the 1500-ft. Glenn sand. Two of the pool's principal operators are repressuring some 500 wells through approximately 130 input wells, virtually all of which are being drilled for that purpose, since the pool has only a relatively small number of abandoned oil wells. At least one operator is preparing to employ water flood on some of its leases, and an expansion of its gas system to other properties.

The above-mentioned 500 repressured wells yield about two thirds of the pool's current output of 6500 bbl. daily, or approximately 4000 bbl., which includes an estimated increase of 2000 bbl. attributable to secondary recovery. Having a daily average production of 3600 bbl. in 1941, the Glenn pool has since shown a consistent increase, as reflected by the following figures:

Year	Daily Average Production, Bbl.	Increase, Per Cent
1941	3,600	
1942 (Repressure started)	4,100	13.9
1943	4,800	17.1
1944	5,800	20.8
Jan. 1945	6,357	

The Glenn pool was discovered in 1904 and as of Jan. 1, 1945, had an accumulated production of some 225,948,000 barrels.

Of importance to the future production potentialities of Oklahoma is the proposed legislation providing for secondary recovery methods. The state's Governor is reported seeking such legislation.

Refiners and manufacturers of natural gasoline are experiencing a good business, which undoubtedly will continue through 1945. A ready market is available for all products at ceiling prices. Oklahoma refiners processed an estimated daily average of 179,000 bbl. of crude during 1944, an increase of 10.5 per cent over the previous year's average of 162,000 bbl. daily, reflecting a less tight crude supply than was being experienced by some of the state's refiners a year ago. This is due, in part, to an increase in the state's production and the utilization of some of the crude imported from Texas through the Stanolind Pipe Line Company's 16-in. line extending from Slaughter, West Texas to Drumright, Okla., which was completed in the early part of the year.

Based on a preliminary study, Oklahoma stripper-well operators are receiving an approximate average subsidy payment of 30¢ per barrel on approximately 97,000 bbl. of oil daily, or $29,100 as a result of the Federal Government's oil subsidy payments which became effective August 1.

Conclusion

In conclusion, it might be said that a vigorous and concerted effort on the part of the industry will be made during the ensuing months to uncover new reserves, increase production, and maintain maximum refinery operations, that Oklahoma may assist in every way possible in meeting the ever increasing demands upon the petroleum industry.

Oil and Gas Developments during 1944 in Pennsylvania

By Charles R. Fettke and Parke A. Dickey,† Members A.I.M.E.

Drilling activity during 1944 increased considerably in the oil fields and slightly in the shallow gas fields of western Pennsylvania. The number of deep tests (middle Devonian or deeper) completed during 1944 was the same as in 1943 and did not result in discoveries of additional reserves of natural gas or oil. Thus far no commercial oil production has been obtained from sands below the Upper Devonian in Pennsylvania. As a result of the lack of new discoveries, oil production in nearly all of the producing areas in the entire Pennsylvania grade region declined 10 to 11 per cent.

Stocks of Pennsylvania Oil

The Pennsylvania grade crude-oil stocks in storage on January 1943 were 2,479,000 bbl. In January 1944 crude stocks totaled 1,846,000 bbl., and during 1944 the stocks of Pennsylvania grade crude declined to a year-ending balance of 1,617,000 bbl. Nearly all of this oil is "unavailable for use," representing pipe-line fill, tank bottoms and limited working inventories at the refineries. The storage of Pennsylvania oil has declined to a point where little or no available crude oil is currently in storage.

Prices

The posted price of Pennsylvania oil remained constant during 1944; however, on Aug. 1, 1944, the wartime Government subsidy was instituted at a rate of 75¢ per barrel. The average price in the Bradford area, including the subsidy, was $3.31 per barrel.

New Technical Developments

The Pennsylvania Grade Crude Oil Association started a rather ambitious program of research in production fundamentals and technology during 1944. Several well-qualified engineers have been employed and a laboratory is to be equipped at Bradford. The group will investigate, in cooperation with the American Petroleum Institute, the possibilities of bacteria as agents in oil recovery, and undertake other studies of both a fundamental and an applied nature.

In cooperation with the Pennsylvania State College, the Research Group worked out a method of measuring water-intake rates in different strata. The method involves injecting salt water down a string of tubing and fresh water down the annulus, determining the location of the interface electrically, and measuring the input rates above and below the interface.

The United States Bureau of Mines, in cooperation with oil companies of the Venango district, developed a simple gas-lift tubing string, which is operating successfully in some 20 wells. This device uses the air-gas mixture produced with the oil to lift it by the usual gas-lift principles. The Northern Ordnance Co. is experimenting with a chamber lift device that expels the oil in an unbroken column. These devices hold considerable promise

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Manuscript received at the office of the Institute July 18, 1945. Published by permission of the State Geologist of Pennsylvania.

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COUNTY			BEAVER-LAWRENCE		ALLEGHENY-WASHINGTON-GREENE		CLARION-BUTLER		CRAWFORD-VENANGO		WARREN-FOREST		McKEAN-ELK	
PERIOD	GROUP		SAND	DEPTH BELOW PGH. COAL	SAND	DEPTH BELOW PGH. COAL	SAND	DEPTH BELOW CORRY SST.	SAND	DEPTH BELOW CORRY SST.	SAND	DEPTH BELOW CORRY SST.	SAND	DEPTH BELOW CORRY SST.
PENNA'N	CONEMAUGH				DUNKARD	500								
UNCONFORMITY														
MISSI'AN	POCONO		(SHENANGO)		BIG INJUN	1150	(SHENANGO)		(SHENANGO)		(SHENANGO)		ABSENT	
	BEREA		BEREA	1200	BEREA	1500	(CORRY)	0	(CORRY)	0	(KNAPP)	0	(KNAPP)	0
DEVONIAN	CONEWANGO	VENANGO SANDS			GANTZ	1850	HUNDRED-FOOT	200-300	VENANGO FIRST	250			(CATTARAUGUS) RED BEDS	
					FIFTY FOOT	1900			RED VALLEY	280				
					UPPER NINEVEH	2025	THIRTY-FOOT	310	LYTLE	320	LYTLE OR SECOND	340		
					LOWER NINEVEH	2050	SNEE	355	VENANGO SECOND	365	SECOND OR SALT	390		
					GORDON STRAY	2100	KNOX THIRD, CLARION	430			CLARION			
					GORDON	2150	BOULDER	440						
					FOURTH	2175	KNOX FOURTH	465	VENANGO THIRD STRAY	410	THIRD	490		
					FIFTH	2225	FIFTH	490	VENANGO THIRD	510	FOURTH	530		
	CANADAWAY	WARREN SANDS	MARINE SHALES								QUEEN	1210		
											CLARENDON, WATSON	1320	SUGAR RUN	1370
									SPEECHLEY	1360	BALLTOWN, CHERRY GROVE	1420	CHIPMUNK	1455
											COOPER, DEERLICK	1620	SECOND, SLIVERVILLE	1570
		BRADFORD SANDS											BRADFORD, THIRD	1895
													LEWIS RUN	1995
													KANE	2135
													HASKELL	2345

FIG. 1.—PRINCIPAL OIL-PRODUCING SANDS OF PENNSYLVANIA.

Data from publications of the Pennsylvania Geological Survey. Accepted names of sands shown. Intervening beds are not named except occasionally, in parentheses, to show equivalents in areas where sands are not productive.

Sands producing only or principally gas are not shown.

TABLE 1.—*Oil and Gas Production in Pennsylvania*

Line Number	Field, *County**	Year of Discovery	Oil Production: Area Proved, Acres	Oil Production: Total Production, Bbl., During 1943	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Wells Producing Dec. 1943: Oil, Artificial Lift	Secondary Recovery	Character of Oil: Gravity A.P.I. at 60°F.	Character of Oil: Sulphur, Per Cent	Producing Formation: Name and Age	Producing Formation: Character	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net
	Allegheny County												
1	Bakerstown-Gold	1887	3,000		575	75				Third and Fourth, Dev	S		
2	Bellevue	1898	400		100	50				Hundred Ft., Third and Fourth, Dev	S		
3	Deer Creek	1900–1913	1,350		270	170				Hundred Ft., Thirty Ft., Third, Fourth, Fifth, Dev	S		
4	Economy-Leetsdale	1885–1886	700		300	100				Hundred Ft., Dev	S		
5	Glenfield	1895	1,250		175	100				Third and Fourth, Dev	S		
6	Glenshaw	1888	1,000		170	95				Hundred Ft., Thirty Ft., Third and Fourth, Dev	S		
7	Imperial	1898–1900	1,900		130	70				Nineveh, Thirty Ft., Dev	S	2,200	10
8	McCurdy, Moon Run, Chartiers	1890–1899	5,500		390	220				Nineveh, Thirty Ft., Fifth, Dev	S	{ 2,100 2,300	10 10
9	Milltown	1893–1917	2,900		210	145				Hundred Ft., Speechley, Dev	S		
10	Moon and Coraopolis	1891–1890	900		190	140				Gordon, Dev	S	2,000	15
11	Shannopin	1885	2,100		240	40				Hundred Ft., Dev	S		
12	Wildwood	1889	2,400		340	140				Hundred Ft., Thirty Ft., Dev	S		
13	Total, Allegheny County		47,400	214,711.37		1,113							
14	Total Armstrong County		7,500	19,988.33		248							
	Beaver County												
15	Crows Run	1895	1,000		165	65				Hundred Ft., Dev	S		
16	Hookstown	1889	700		x	25–30				Berea, Mis	S		
17	Kendall	1914–1915	300		90	70	A			Berea, Mis	S		
18	New Galilee	1885	2,300		460	60				Berea, Mis	S		
19	Smith's Ferrys—Ohioville	1864–1865	4,300			180	A			Berea, Mis	S		
20	Total, Beaver County		12,000	24,570.79		436							
	Butler County												
21	Annisville-Ferris	1916	840							Ven, First, Dev	S		
22	Brush Creek, Ingomar Keown	{ 1887–1889–1922 1893	5,000		550	400				Snee, Boulder, Dev	S	850	15
23	Bullion-Clintonville		970 1,200							Venango Second and Third, Dev	S	{ 1,000 1,200	10–30 10–20
24	Butler Cross-Belt	1874	{ 7,000 4,850							Knox Third and Fourth, Dev	S	{ 1,480 1,450–1,600	30 25
25	Byram		1,600							Venango Third, Dev	S		
26	Camp Run	Old	300			None				Hundred Ft., Berea, Dev	S		
27	Cherry Valley	1900	2,640							Venango Second, Dev	S	1,025–1,225	25–45
28	Chicora	1875	{ 9,000 5,000							Venango Third and Fourth, Dev	S		
29	Crider and Peters	1896	650		115	40				Hundred Ft., Snee, Boulder, Dev	S		

30	Crooked Run and Oneida	1860–1885	15,000		700	200				Hundred Ft., Third, Dev	S		
31	Evans City, Glade, Ramsey	1892–1890	15,000		Mostly abandoned	250				Hundred Ft., Snee, Third, Fourth, Dev	S		
32	Garvin and Callery	1893–1910	1,700			Few				Hundred Ft., Dev	S		
33	Glade Mills	1876	5,000			None				Hundred Ft., Fourth, Dev	S		
34	Hooker	1901	4,300		A					Speechley, Dev	S	2,150–2,350	20
35	Hoover	1892	2,000					46.5	<0.1	Venango Third, Dev	S	1,200–1,500	10–30
36	Mars	1890	1,400			Less than 25				Hundred Ft., Dev	S		
37	Muddy Creek and McCandless	1891	2,000		180	150				Berea, Mis	S		
38	Parker	1869	1,800 10,000							Hundred Ft., Venango Third, Dev		1,280 800–1,400	12 20
39	Saxonburg	1886	5,000		600	100–200				Third, Fourth, Fifth, Dev			
40	Shira	1893	1,360					50.1	<0.1	Venango Third, Stray, Dev		1,350	3–12
41	Thorn Creek	1882	10,000		900	100				Hundred Ft., Third, Fourth, Dev			
42	Zelienople	1900	500			None				Hundred Ft., Dev			
43	Total Butler County		75,000	312,674		4,632							
	Clarion County												
44	Clarion		2,150							Knox Third, Dev		900	15
45			1,050							Knox Fourth, Dev		950	10
46	Knox	1874	200							Red Valley, Dev		1,000	5–20
47			300							Boulder, Dev		1,100	5–10
48			17,850					43.8		Knox Third, Dev		980–1,130	7–35
49			675							Knox Fourth, Dev		1,000–1,200	5–20
50			580							Knox Fifth, Dev		1,100–1,200	10
51	Rattlesnake		550							Hundred Ft., Dev		900	15–20
52	Total Clarion County		30,000	90,439		2,070							
	Crawford County												
53	Church Run							41		Venango Third, Dev			
54	for Church Run see Venango County												
55	Total Crawford County		6,500	60,019		1,222							
	Elk County												
56	Glen Hazel						W			Bradford, Dev			
57	Kane									Kane, Dev		2,200	
58	Sackett									Kane, Dev			
59	Total Elk County		12,000	62,162		1,241							
	Forest County												
60	Balltown	1882	2,500							Balltown, Dev		1,200–1,800	10–30
61	Cooper	1881	400							Watson or Second, Dev			
62			2,250							Cooper, Dev		1,800	15
63	Marienville		300							Clarion (Venango), Dev		400–1,000	10–30
64	Red Brush		400							Venango Second, Dev		750–1,000	10–25
65	Watson Farm-Duhring	1890	3,900							Watson or Second, Dev			
66			250							Kane, Dev			
67			150							Elk, Dev			
68	West Hickory	1870	450							Venango First, Dev			
69			450							White (Red Valley), Dev			
70			350							Lytle, Dev			
71			3,300							Venango Third, Stray, Dev			
72	Total Forest County		14,500	63,143		1,370							

* For special explanation of subjects see pages 473 to 474.

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres	Oil Production: Total Production, Bbl., During 1943	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Wells Producing Dec. 1943: Oil, Artificial Lift	Secondary Recovery	Character of Oil: Gravity A.P.I. at 60°F.	Character of Oil: Sulphur, Per Cent	Producing Formation: Name and Age	Producing Formation: Character	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net
	Greene County												
73	Brave	1899	400		45	15				Gordon, Fourth, Fifth, Bayard, Dev		3,150 3,300	15[1] 9[2]
74	Bristoria	1891–1897	11,000		500	350				Gordon Stray, 4th, 5th, Dev Injun, Mis, 50-30, Gordon, Dev		3,150 3,350	15[3] 7[4]
75	Dunkard-Greensboro	1863–1864	600		220	120				Big Dunkard, Mis		900	15
76	Fonner	1897	450		50	8–10				Gantz, Dev		2,800	15
77	Mt. Morris	1886	300		35	21				Big Injun, Mis		1,800	15
78	Shannon Run	1919	400		44	37				Big Injun, Mis Bayard, Dev		1,900 3,050	10 10
79	Total Greene County		13,855	129,177		681							
80	Total Jefferson County		3,200	5,386		139							
	Lawrence County												
81	Bessemer	1906	7,000							Berea, Mis		600–800	10–35
82	Slippery Rock	1864	100			None				Mississippian		200	
83	Total Lawrence County		7,100	832		254							
	McKean County												
84	Bradford	1871	85,000				W			Bradford, Dev[5] Chipmunk, Dev Second, Dev Lewis Run, Dev		1,500 1,060 1,175 1,600	30
85	Music Mountain	1937	670				G			Sliverville, Dev		1,500	35
86	Sugar Run						G			Sugar Run, Dev			
87	Kushequa									Kane, Dev		2,000	30
88	Kanesholm (Burning Well)						W			Bradford, Dev		2,200	20
89	Total McKean County		87,920	13,154,544		34,759							
	Mercer County												
90	Volant	1906	3,200				A			Hundred Ft., Dev		600–925	12–25
91	Raymilton									Venango Third, Dev	See Venango County		
92	Total Mercer County		6,000	8,567		247							
93	Hebron	1910	85	48,000		30	W			Hebron (Bradford horizon), Dev		1,400	10
94	Total, Potter County		1,000	60,921		231							
	Tioga County												
95	Gaines	1898	200	6,000	150	53	W			Atwell, Dev		775	16–20
96	Total Tioga County		200	6,000									
	Venango County												
97	Black Hill	1873	730							Red Valley, Dev		550–960	25
98	Breedtown		1,200							Venango Third, Stray		750–850	
99	Bullion-Clintonville	1860	11,700				W	34.0		Venango Second, Dev		850–1,250	10–20

100			4,785					38.4		Venango Third, Dev		600–1,300	10–30
101	Cherrytree		875				A	43.6		Venango Third, Dev		700–900	20–35
102	Cornplanter	1861	8,050				A	37.2		Venango Second, Dev		460–850	20–35
103			4,000							Venango Third, Dev		600–1,000	8–25
104	Emlenton-Richey Run	1879	1,860					36.8		Boulder, Dev		1,150–1,375	10
105			5,000					43.8		Venango Third, Dev		1,200–1,425	25
106	Foster-Reno	1860	18,270				A	36.2		Venango Second, Dev		450–1,080	5–25
107			2,890							Venango Third, Stray, Dev		500–1,000	10–40
108	Foster-Reno		1,800					43		Venango Third		550–1,230	10–25
109	Franklin	1859	6,820				Exptl Mine Shaft	32.3		Venango First, Dev		250–700	10–85
110	Hamilton Corners	1904	1,000				A	44		Venango First, Dev		400–600	10–40
111	Hampton-Strong	1885	1,400					41.7	<0.1	{ Red Valley, Dev { Venango Second, Dev		625–825 825–975	12–25 10–45
112			5,500					46		Venango Third Stray, Dev		750–1,050	10–20
113	Hill City	1885	400				G			Venango Third, Dev		900	38–45
114	Oakland		600							Venango First, Dev		500–700	9–20
115	Octave	1870	1,360				A			Venango Third, Dev		450–850	10–60
116	Petroleum Center—Pioneer	1861	1,670				A			Venango First, Dev			
117			3,000					35.6		Venango Second, Dev			5–30
118			3,800					47.2		Venango Third, Dev		450–500	5–40
119	Pithole	1865	2,200				A	43.2		Venango First, Dev		550–650	10–30
120			4,000							Red Valley Lytle, Dev		650–750	10–20
121			1,200							Venango Second, Dev		700–800	10–20
122			2,000							Venango Third, Stray, Dev		750–850	8–15
123	Pleasantville	1868	4,400				A	42		Venango First, Dev		550–650	20–40
124			3,400					45–47		Lytle, Red Valley, Dev		550–650	10–25
125			5,100					42–43		Venango Second, Dev		600–700	10–30
126			7,000					49		Venango Third, Stray, Dev		650–750	10–20
127			2,000							Venango Third, Dev		700–800	10–25
128	Plummer-Walnut Bend	1861	6,500				A			Lytle, Red Valley, Dev		250–675	5–23
129	Rattlesnake	1870	450				A			Venango First, Dev		500–700	10–30
130			1,150					47		Lytle, Red Valley, Dev		600–800	10–20
131			1,200							Venango Second, Dev		650–800	10–20
132			600							Venango Third, Stray, Dev		750–900	
133	Raymilton	1898	1,570							Venango Third, Dev		760–1,080	10–30
134	Shamburg	1866	5,000				A	42.3		Venango Third, Dev		550–750	10–50
135	Speechley	1885	800							Speechley, Dev		1,920	40
136	Van	1888	800					46.7	<0.1	Venango First, Dev		800	10–20
137			6,100							Venango Third, Stray, Dev		870–1,150	30
138	Total Venango County		114,600	758,778		23,557							
	Warren County												
139	Bull Hill	1899								Included in Clarendon pool			
140	Clarendon	1878	19,000				W			Clarendon, Dev		975–1,400	15–30
141	Colorado-Grand Valley		2,750							Venango First, Dev		250–500	10–30
142			7,400					42–45		Venango Third, Stray, Dev		500–800	
143	Cooper	1880	450				G			Balltown, Dev		1,250–1,800	12
144			4,000							Cooper		1,300–2,000	10–25
145	Cherry Grove	1882	2,000							Cherry Grove		1,500–1,800	5–20
146	Deerlick	1900	350							Deerlick		1,600–2,050	20
147	Selkirk		1,000				A	43		Venango First		300–500	10–35
148			100							Venango Third, Stray		500–700	10–20
149	Tidioute	1860	400							Venango First		300–600	

[1] Fourth. [2] Bayard. [3] Gordon. [4] Fifth. [5] Dome. Deepest horizon tested: Queenston (Ord).

TABLE 1.—(*Continued*)

Line Number	Field, *County**	Year of Discovery	Oil Production: Area Proved, Acres	Oil Production: Total Production, Bbl. During 1943	Number of Oil and/or Gas Wells. Completed to End of 1944	Wells Producing Dec. 1943: Oil, Artificial Lift	Secondary Recovery	Character of Oil: Gravity A.P.I. at 60°F.	Character of Oil: Sulphur, Per Cent	Producing Formation: Name and Age	Producing Formation: Character	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net
150			1,600					47–48		Lytle-Red Valley		400–600	
151			2,600					43–46		Venango Third, Stray		130–730	
152			100							Venango Third Queen		900–1,400	
153			800							Glade		500–1,300	20
154	Warren	1875	10,500							Clarendon, included in Clarendon pool Gartland	ol	900–1,500	5–40
155	Total Warren County		55,000	500,490		8,586							
156	*Washington County*												
157	Cannonsburg, McMurray	1888	1,900		125	75				Fourth, Fifth, Gordon, Gantz, 50 Ft.		2,400	15
158	Cross Creek	1900	2,500		500	300				Hundred Ft.		2,000	10
159	Florence and Five Points	1899	3,600		215	165				Hundred Ft.		1,800	10
160	McDonald and Venice	1891–1894	20,000		1,600	900	G			Gordon Fourth Fifth		2,300 2,350 2,400	15 10 15
161	Taylorstown	1885	7,700		250	200	G			Gordon Fourth, Fifth		2,600	10
162	Washington	1885	11,500			400				Gantz, Fourth, Fifth		2,600	10
163	Total Washington County		39,415	306,296		1,494							
164	Total, Pennsylvania		533,090	15,772,705		81,761							

for reducing lifting costs in the air-drive and gas-drive areas.

The experimental water-flooding project undertaken by the Forest Oil Corporation of Bradford in the Venango Second sand, in the Clintonville pool, southwestern Venango County, in 1943 has not proved successful. The company practically suspended operations in the test in 1944. It was found that in many places old and imperfectly plugged wells had given water access to the oil sand. In some places the water was found (by electrical tests) in the upper few feet of sand, presumably originally gas-bearing, while in others it was all through the sand body. In September the Quaker State Oil Refining Corporation purchased the Clintonville properties, along with other Forest interests in Pennsylvania, and started to drill the central producing wells. Two had been drilled by the end of the year and were producing a few barrels of oil daily together with considerable amounts of water.

TABLE 2.—*Oil Production in the State of Pennsylvania*, 1937–1944

Year	Bradford Field		Central and S. Pennsylvania Oil Production, Bbl.	State of Pennsylvania Oil Production, Bbl.
	Wells Completed[a]	Oil Production, Bbl.[b]		
		Total		
1937	4,112	15,076,909	4,108,100	19,185,109
1938	2,148	13,417,102	4,008,923	17,426,025
1939	2,114	12,899,104	4,438,035	17,337,139
1940	3,004	12,748,279	4,604,763	17,353,042
1941	3,207	12,729,900	4,104,100	16,834,000
1942	3,113	14,160,000	3,663,870	17,823,870
1943	2,255	12,446,634	3,395,965	15,842,599
1944	2,434	11,096,754	3,038,532	14,135,286
		Daily Average		
1937		41,300	11,255	52,555
1938		36,759	10,983	47,742
1939		35,340	12,159	47,499
1940		34,831	12,581	47,412
1941		34,876	11,244	46,120
1942		38,795	10,038	48,833
1943		34,100	9,304	43,404
1944		30,319	8,302	38,621

[a] Includes oil and water-intake wells in New York state part of Bradford field.
[b] Production within state of Pennsylvania only.

Work on the experimental mine shaft with horizontal holes into the Venango First sand in the old Franklin heavy-oil pool at Franklin, Venango County, continued throughout the year, although results were disappointing. Two holes were drilled a distance of about 2300 ft. radially from the shaft and were shot. Another pair was drilled 1000 ft. and a third pair 700 ft. from the shaft. These holes have not been shot. Drilling is continuing, but slowly because of manpower and equipment shortages.

PRODUCTION

The continued decline of production of Pennsylvania grade crude oil during 1944 was caused primarily by limited areas for the extension of water-flood production in the Bradford and Allegany fields. The necessary wartime restrictions make it more difficult for the small operators to carry on development work, for while materials have been available, the shortage of manpower for drilling and producing operations has definitely slowed the rate of new work. Well completions actually increased with a small increase in the Bradford field and a substantial increase in Central Pennsylvania, due to the development work by Northern Ordnance Company.

The total production within the state of Pennsylvania was 14,135,286 bbl. for 1944, as compared with a production of 15,842,599 bbl. during 1943. Production statistics for the various districts producing Pennsylvania grade oil are given in Table 3. The percentage decline in oil production for 1944 was similar to the percentage decline that occurred during 1943 (as compared with 1942). The bulk of the reduction occurred in the Bradford field, but the percentage decline was comparable to that of the remainder of Pennsylvania. The Bradford-field production within the state of Pennsylvania declined from 12,446,634 bbl. in 1943 to a 1944

TABLE 3.—*Production of Pennsylvania Grade Oil in* 1944

Month	Bradford Field		Allegany	Central and South Pennsylvania	Ohio	West Virginia	Total
	Pennsylvania	New York					
January	30,595	2,906	9,508	8,249	4,387	8,355	64,000
February	31,346	3,127	10,050	8,236	4,310	8,759	65,828
March	32,321	3,019	9,785	8,520	4,452	8,709	66,806
April	31,481	2,557	9,518	8,377	4,100	8,300	64,333
May	32,181	3,077	10,354	9,582	4,522	9,032	68,748
June	30,487	3,941	10,430	8,742	4,133	8,600	66,333
July	27,561	2,431	8,234	5,774	3,000	7,226	54,226
August	34,129	3,249	11,913	10,289	5,065	9,451	74,097
September	29,673	3,038	10,036	8,986	3,967	8,400	64,100
October	28,312	2,874	9,741	8,879	4,484	8,516	62,806
November	28,710	2,748	9,895	7,780	3,633	8,267	61,033
December	26,552	2,515	9,060	6,219	3,323	7,064	54,742
Daily average	30,319	2,912	9,874	8,302	4,131	8,388	63,926

TABLE 4.—*Shallow Well Completions in Gas Fields in Southwestern Pennsylvania in* 1944

County	Completions		Gas			Oil			Dry	
	Number of Wells	Average Total Depth, Ft.	Number of Wells	Average Initial Open Flow, M Cu. Ft. per Day	Average Total Depth, Ft.	Number of Wells	Average Initial Production, Bbl. per Day	Average Total Depth, Ft.	Number of Wells	Average Total Depth, Ft.
Allegheny	36	2,863	27	304	2,816	1	5	1,700	8	3,167
Armstrong	102	2,876	94	122	2,874	0			8	2,894
Beaver	3	1,094	1	114	1,163	1	2	1,060	1	1,059
Butler	31	1,674	9	36	2,060	13	2	1,527	9	1,498
Fayette	69	2,701	45	495	2,698	1	15	1,873	23	2,745
Greene	86	2,886	67	298	2,825	0			19	3,099
Indiana	32	3,013	20	68	3,143	0			12	2,797
Lawrence	3	744	1	20	748	0			2	741
Washington	52	2,436	38[a]	370	2,434	3	11	1,815	11	2,605
Westmoreland	59	3,168	36	192	3,282	0			23	2,990
Total	473	2,745	338	251	2,813	19	4.2	1,576	116	2,737

[a] Includes two gas-storage wells.

TABLE 5.—*Shallow Well Completions in Gas Fields in Northern and Central Pennsylvania in* 1944

County	Completions		Gas			Dry	
	Number of Wells	Average Total Depth, Ft.	Number of Wells	Average Initial Open Flow, M Cu. Ft. per Day	Average Total Depth, Ft.	Number of Wells	Average Total Depth, Ft.
Clarion	79	2,308	62	62	2,250	17	2,523
Clearfield	8	3,086	3	866	2,779	5	3,271
Elk	83	2,420	58	107	2,585	25	2,537
Forest	29	1,885	20	165	2,019	9	1,587
Jefferson	96	2,840	72	143	2,767	24	3,059
McKean	64	2,298	45	94	2,283	19	2,334
Mercer	13	935	8	57	764	5	1,207
Venango	7	2,021	7	63	2,021	0	
Warren	22	1,786	12	545	1,367	10	2,289
Total	401	2,364	287	139	2,358	114	2,378

total of 11,096,754, or a daily average of 30,319 bbl. The daily average total production for the state of Pennsylvania was 38,621 bbl., as compared with a daily average during 1943 of 43,404 bbl. Nearly all of the producing areas in the entire Pennsylvania grade region declined 10 to 11 per cent.

Tabular Data on Pennsylvania Oil Pools

In Pennsylvania there are no state regulatory bodies nor any other organizations that make a practice of collecting data on oil and gas development, such as are included for other states in this A.I.M.E. symposium. In fact, there exists a surprising indifference on the part of the operators to the activity of their contemporaries.

This situation is not due to the lack of activity because of the depleted condition of the pools. On the contrary, more wells are drilled yearly in Pennsylvania than in any other state except Texas, and many of these are wildcats. Drilling is cheap, and wildcats, or at least semiexploratory wells, are continually being drilled, both for oil and for gas. Often no record is kept of either the location or the log of these wells by the operator himself, and no effort is made on the part of any public agency to do so. A few gas companies employ scouts, but no oil company does so. Pipe-line companies report their total runs frequently to the A.P.I. and once a year to the State Bureau of Statistics. No effort is made to segregate runs by fields or pools.

TABLE 6.—*Deep Tests Completed and Drilling in Western Pennsylvania in* 1944
DEPTHS IN FEET

Line No.	County	Township	Well	Company	Elevation, Feet Above Sea Level	Berea	Tully
1	Beaver........	Harmony	Spang Chalfant	National Supply Co.	767	1,050–1,081	5,063–5,068
2	Butler.........	Mercer	Jessie C. Hockenberry No. 1	Manufacturers Light and Heat Co.	1,306	728–741	4,482–4,532
3	Clearfield.......	Bell	Alice Irwin No. 10	F. C. Deemer	1,961		
4	Crawford......	Beaver	Alfa Cozadd No. 1	Appalachian Dev. Corp.	1,027		
5	Crawford......	Beaver	Fred Walton No. 1	Appalachian Dev. Corp.	1,006		
6	Crawford......	East Fallow field	Ellen Calvin No. 1	The Sylvania Corp.	1,342		3,083–3,127
7	Elk............	Highland	Warrant 3653 No. 1	Pennsylvania Gas Co.	1,572		5,141–5,177
8	Fayette........	Georges	Wm. R. Barton No. 4	Greensboro Gas Co.	2,370		6,425–6,505
9	Fayette........	Georges	Wm. R. Barton No. 5	Greensboro Gas Co.	2,190		6,118–6,194
10	Fayette........	South Union	Leo F. Heyn No. 1	New Penn Dev. Corp. and Wm. E. Snee	2,316		6,021–6,100
11	Fayette........	South Union	Leo F. Heyn No. 3	New Penn Dev. Corp. and Wm. E. Snee	2,314		5,845–5,915
12	Fayette........	Wharton	J. R. Thompson Heirs No. 1	New Penn Dev. Corp.	2,316		6,930–
13	McKean.......	Lafayette	Warrant 3416 No. 4	South Penn Oil Co.	2,141		4,467–4,469
14	Mercer........	Worth	Maude Davidson No. 1	United Natural Gas Co.	1,430		3,837–3,882
15	Tioga.........	Lawrence	Dean Colegrove No. 1	New York State Natural Gas Co.	1,680		3,004–3,069
16	Venango.......	Jackson	Clyde Van Camp No. 1	Hathaway Brothers	1,592		3,700–3,775
17	Warren........	Corydon	E. A. Williams No. 1	Appalachian Dev. Corp.	1,266		3,123–3,148
18	Warren........	South West	Reeves Farm	Northern Ordnance, Inc.			
19	Washington....	Cross Creek	J. E. McCullough No. 1	The Texas Co.	1,258		
20	Westmoreland..	Derry	Camilla F. Giffin No. 2	The Peoples Natural Gas Co.	2,261		

For these reasons it has been considered impossible to present data on Pennsylvania oil and gas production in a manner similar to that of other states. During the last few years, however, more data have become available. In 1941 the Petroleum Administration for War requested data on all the oil pools in the state. Material on the Bradford area was provided by a committee of operators, that on the Kane-Butler or Middle district by the Pennsylvania Topographic and Geologic Survey, and that on the Southern district by a committee of operators. For some time the Bradford District Producers Association has attempted to keep track of the number of wells drilled in the Bradford field, by obtaining from the well-shooting companies the total number of wells shot with nitroglycerin. Recently these records have been obtained for the rest of the state.

It is believed therefore that it might be advantageous to attempt to compile the information available in tabular form, even though it is incomplete and sometimes approximate or even erroneous. It is hoped that in future years the entries may be made more complete and correct. The authors very earnestly request the assistance and cooperation of members of this association and others in correcting and improving this table.

The sources of the tabular data are various and sometimes conflicting. No attempt has been made to reconcile conflicts, and the information is presented (Table 1) merely for what it is worth.

TABLE 6.—(*Continued*)

Line No.	Top Onondaga	Oriskany	Lockport	Medina	Top Trenton	Top Beekmantown Dolomite	Top Upper Cambrian Sandstone	Total Depth, Ft.	Date Completed	Results
1	5,315	5,471						5,484	4/ 7/44	Salt water from Oriskany rose 1500 ft. in 12 hr.
2	4,702	4,828–4,841	5,935–6,185	6,453–6,633	8,812	9,553	10,074	10,096	11/19/44	Show of gas 9,505–9,510 and 9,746–9,771. Salt water at 10,096 ft.
3										Drilling at 3,554 ft.
4	2,142	2,388–2,394						2,404	10/ 5/44	190 M cu. ft. per day open flow after casing, 650 lb. per sq. in. Oriskany
5	2,144	2,390–2,399						2,427	12/ 3/44	6¼ bailers salt water; show of oil; Oriskany
6	3,242	3,431–3,448	4,190–4,421					4,644	8/29/44	Hole full of salt water from Oriskany. Show of gas 4,398–4,421; salt water 4,421
7	5,545	Absent								Drilling deeper
8	6,988 Top chert 7,012	7,340–7,497						7,510	1/27/44	1,250 M cu. ft. initial open flow flow from Onondaga chert
9	6,795 Top chert 6,823	7,073–7,209						7,242	12/ 8/44	690 M cu. ft. initial open flow Oriskany 7,073–7,076
10	6,572 Top chert 6,593	6,777–6,848						8,450	2/24/44	Deepened from 7,508. No additional gas
11	6,393 Top chert 6,394	6,566–6,671						8,002	4/14/44	Deepened from 7,460. No additional gas
12	7,464	7,638								Drilling at 7,746 ft.
13	4,816	4,874						4,903	2/21/44	One bailer salt water per hour from Oriskany
14	4,050–4,172	Absent	5,200–5,456	Absent	8,177	8,834		8,892	1/11/45	69 M cu. ft. initial open flow in Lockport at 5,399; show of gas at 8582. Salt water in dolomite at 8,876–8,892
15	3,921	3,945						4,016		Drilled for gas storage
16	3,945	4,090						4,096	4/22/44	Salt water at 4,094. Producing a little oil from sand at 918–930
17	3,444	3,526–3,536						3,542	8/25/44	2½ bailers salt water in 1½ hr. from Oriskany
18										Drilling at 2,650 ft.
19										Drilling at 4,307 ft.
20										Drilling at 6,694 ft.

1. *Field and County.*—For many pools there is no generally accepted name. Those shown are used in the publications of the Pennsylvania Geological Survey.

2. *Year of Discovery.*—The date of discovery has been taken from state and federal Geological Survey publications.

3. *Area Proved.*—Bradford field, from C. R. Fettke: The Bradford Oil Field, 1938.

McKean, Clarion, Mercer, Lawrence, and parts of Forest and Warren Counties, planimeter measurements by Pennsylvania Geological Survey of preliminary and rather unreliable maps.

Venango, Crawford, and parts of Forest and Warren Counties, planimeter measurements of accurate oil-field maps prepared by the Pennsylvania Geological Survey. In this area the acreage is given *by sands*. Inasmuch as the sands overlap, the sum of the acreages given is not the total area of the pool, but considerably in excess of that acreage.

Butler, Beaver, Allegheny, Washington and Greene Counties, acreage estimated by committee of operators for the Petroleum Administration for War. The total checks reasonably well with an independent measurement by the Pennsylvania Geological Survey.

Parts of some pools and all of others are abandoned. No effort has been made to separate the abandoned areas, and they are therefore included.

The totals by counties are based on estimates made by the Pennsylvania Geological Survey, and are only roughly equal to the sum of the estimates of the individual pools.

4. *Oil Production.*—Except for a few pools in southwestern Pennsylvania, early production data have long since been lost, so that total production data will never be available. Estimates of daily oil production are made weekly by the American Petroleum Institute for the Bradford, Kane-Butler, and southwestern Pennsylvania areas. Yearly estimates are made by the Bureau of Statistics, separated by counties. These are not completed for several months after the end of the year, so that the estimates for 1944 are not available. Those for 1943 are given instead.

5. *Gas Production.*—No attempt is made to estimate gas production. For the oil pools listed, it is negligible, and probably altogether more gas is purchased for operating than is sold off the leases.

6. *Number of Oil Wells.*—For Beaver, Allegheny, Washington, and Greene counties the P.A.W. committee attempted to estimate the total number of wells that had been drilled in each pool. These pools are more recent and deeper than the pools in the rest of the state. The older and shallower pools have been redrilled as many as four times, and it is considered quite hopeless to even guess at the total number of wells.

7. *Wells Producing December* 1943.—The P.A.W. committee estimated the number of wells in the southwestern counties producing in 1941, by pools. The number has changed since, but the data in Table 1 are given for what they are worth. The Bureau of Statistics, along with the production by counties, publishes the number of wells connected as of December 31, as reported to the Bureau by the pipe-line companies. However, the gaugers often make no effort to report the actual number of wells on their run tickets, so these estimates are considered quite unreliable.

8. *Reservoir Pressure.*—The reservoir pressure in all wells is low, as the pools have been on unrestricted production for many years. Actual measurements are almost lacking.

9. *Secondary Recovery.*—Any secondary-recovery operation known to the authors is shown as *A*, air drive; *G*, gas drive; and *W*, water drive; regardless of its extent or intensity. In most pools only a small fraction of the area is subjected to secondaıy methods, and then rather inefficiently and ineffectively. The only pools where a considerable portion of the area is under secondary methods are Bradford (water drive) and Goodwill Hill-Colorado, Cornplanter, Hamilton Corners, Octave, Petroleum Center-Pioneer, Shamburg (air drive), and Taylorstown and McDonald (gas drive). Accidental water encroachment is known to be taking place in certain pools, but these are not indicated.

10. *Character of Oil.*—The gravity of oil is taken from Hempel analyses by the U. S. Bureau of Mines. All oil is sold as Pennsylvania grade. All pools contain oil remarkably similar in character, except for oil from the Venango Second sand, and from the Venango First sand in the Franklin pool only. These crudes are

lower in A.P.I. gravity, have a smaller percentage of light gasoline and naphtha, and the light fractions are somewhat more naphthenic.

11. *Producing Formation.*—All oil fields in Pennsylvania produce from lenticular sand bodies. All pools are thus primarily stratigraphic in character, although often affected by structure. Only a minority of pools have downdip edge water, and in only one pool (Guffey) is there evidence of edge-water encroachment.

The lenticular character of the sand bodies makes correlation of the horizons in the ordinary manner difficult. The general picture is that of a series of long belts or zones, a few miles wide, trending usually northeast-southwest, in which a given horizon is locally productive. Very seldom is the same horizon productive outside these belts. The productive zones appear to be associated with the facies change from a continental environment on the east to a marine environment on the west, and have many characteristics of shoreline and near-shore sand bars.

Table 1 serves to show roughly the relation of the producing formations as identified for the pools.

The depth to top of producing zone is a rough estimate. The country is rugged, with a relief of as much as 500 ft. or more in any one pool. Differences in depth do not necessarily give the interval between horizons. The productive thickness as given is usually the "pay," with the shale and impermeable beds subtracted, and in others is the gross formation thickness, of which as much as 50 per cent is deductible because of impermeability.

Shallow-sand Developments

Gas

During 1944, in the shallow-sand gas territory of western Pennsylvania, 855 wells were completed as compared with 770 in 1943, an increase of 11 per cent. Of the shallow wells drilled for gas, 73 per cent were producers and 27 per cent were dry. The 625 new gas wells had a total initial open-flow capacity of 124,684,000 cu. ft. of gas per day, as compared with the total initial open-flow capacity of 147,282,000 cu. ft. of the 579 new gas wells completed in 1943.

Southwestern Pennsylvania.—Shallow well completions in southwestern Pennsylvania are shown in Table 4. The 338 new gas wells had a total initial open-flow capacity of 84,784,000 cu. ft. of gas per day. No new gas pools of significant size were discovered in southwestern Pennsylvania during 1944.

Northern and Central Districts.—A summary of activities in the shallow gas territory of the northern and central districts during 1944 is given in Table 5. The 287 new gas wells had a total initial open-flow capacity of 39,900,000 cu. ft. of gas per day. The average initial open-flow capacities of the wells shown for Clearfield and Warren counties (Table 5) are large because the averages in these counties have been distorted by the completion of a few exceptionally large wells.

A Haskell-sand gas pool was opened in Hamlin township in southwestern McKean County early in 1944. By the end of the year nine producing wells and two dry holes had been drilled, proving an area of about 275 acres without defining the limits of the pool. Depth of sand ranges from 2470 to 2530 ft. The wells have an average initial open-flow capacity of 160,000 cu. ft. per day, individual wells ranging from 60,000 cu. ft. to 438,000. Initial reservoir pressure was 800 lb. per sq. in. During the latter part of the year, the pool was producing about 10,000,000 cu. ft. of gas per month.

Three shallow gas wells were completed on the east side of the Allegheny River between Kinzua and Corydon, in northeastern Warren County, during the summer of 1944, and may lead to the development of a Clarendon-sand gas pool of some magnitude, as the maximum distance between the wells is 4600 ft. and no wells had been drilled previously in the immediate vicinity. Depth of sand ranges from 650 to 720 ft. The wells had initial

open-flow capacities of from 54,000 to 1,000,000 cu. ft. per day. Reservoir pressures reported vary from 260 to 475 lb. per sq. in. As the discovery lies a considerable distance north of any present producing gas fields, no pipe-line connection had been made by the end of the year.

Oil

A considerable increase in drilling activity occurred in the oil fields of western Pennsylvania, 3375 new wells being completed in 1944 as compared with 2617 in 1943, an increase of 29 per cent. Almost all of the drilling was done in connection with secondary-recovery operations, either water-flooding or air and gas-drive projects.

In the Bradford field (Table 2) 2436 new wells were drilled, about half of which were water-intake wells, which compares with 2255 in 1943, an increase of 8 per cent. The field accounted for 52 per cent of the total Pennsylvania grade crude-oil production of the Appalachian province in 1944.

The number of new wells completed in the central and southwestern districts of Pennsylvania in 1944 was 939, as compared with 499 in 1943, an increase of 88 per cent. A large part of this increased activity was due to the extensive development campaign conducted by the Northern Ordnance Co. of Minneapolis, Minn., in the Venango district. A newcomer in the Pennsylvania oil fields, the Company and its affiliates purchased 17,000 acres of oil lands in Venango and Warren Counties, on which are located 1500 wells with an annual production of about 150,000 bbl. The company embarked on an intensive secondary-recovery program and drilled 180 air-input and 230 oil-producing wells during 1944.

The daily average production in the central and southwestern districts of Pennsylvania declined from 9,154 barrels in 1943 to 8,468 barrels in 1944, or 7.5 per cent. The total production in 1944 of these two districts approximated 3,099,300 barrels, or 13.2 per cent of the total Pennsylvania grade production.

Deep-sand Developments

The results of deep drilling in western Pennsylvania during 1944 are summarized in Table 6. Of the 12 wells completed, three encountered commercial volumes of gas, one was drilled for gas storage, and eight were dry. Two of the successful wells are in the southern extension of the Summit gas pool in Fayette County. The two wells deepened in the Summit pool did not encounter any additional quantities of gas. One of these, the Heyn No. 1, was bottomed in anhydrite and salt beds in the lower part of the Salina formation. Drilling was stopped by caving in these beds.

The Alfa Cozadd well, in the northwestern part of Crawford County, had an initial open-flow capacity of 190,000 cu. ft. of gas per day from the Oriskany sandstone after casing and a reservoir pressure of 650 lb. per sq. in. A number of wells had been drilled to the Oriskany in the vicinity in previous years. All of these encountered salt water in the sand and some had good shows of both oil and gas. Elevations on top of the sand suggested the possible presence of a dome of moderate relief and size at the site of the Cozadd well. This was verified by drilling but a later offset well, which was lower on structure and encountered salt water, indicated that the productive area cannot be very large. With a sand thickness of only 6 to 9 ft., therefore, no significant reserve of gas was opened by the discovery. The E. A. Williams No. 1 well, in the northeastern corner of Warren County, represents another unsuccessful attempt to find a stratigraphic trap-type gas pool in the Oriskany sandstone, which feathers out updip northwest.

Of the dry holes, the Jessie C. Hockenberry No. 1 of the Manufacturers Light and Heat Co., Mercer township, north-

western Butler County, was the most interesting, both from a stratigraphic standpoint and from the depth attained with cable tools. The well started a short distance above the Vanport limestone in the Allegheny group of the Pennsylvanian system and was bottomed in a quartzose sandstone underlying 520 ft. of Lower Ordovician dolomite, probably Beekmantown in age. Salt water was encountered in the sandstone. Acidizing did not increase the small flow of gas encountered in the dolomite. The well reached a total depth of 10,096 ft. and is now the deepest well in the Appalachian province, and also the deepest well that has been drilled entirely with cable tools.

Bibliography

Special Bulletin No. 1, Pennsylvania Geological Survey, Fourth Series, on the Oil-Bearing Sands in Southwestern Pennsylvania, a preliminary report prepared by L. S. Matteson and D. A. Busch, was the most informative publication relating to the geology of the oil and gas fields of western Pennsylvania to appear in 1944. This is a folio of 55 maps and sections, 12 by 15 in., accompanied by 16 folio-size pages of text and descriptive matter and selected well records. It shows where the several sands of the Venango group from the Gantz and Fifty-foot to and including the Fifth have been productive of oil and gas in southwestern Pennsylvania and where they play out or are unproductive. The area covered includes most of Greene and Washington Counties, the southwestern part of Allegheny County, and a narrow strip along the southern border of Beaver County.

Acknowledgment

In connection with the preparation of this review, the writers wish to acknowledge the cooperation of F. H. Finn, John T. Galey, D. T. Secor, and A. C. Simmons, and the staffs of the Pennsylvania Geological Survey and the Bradford District Oil Producers Association, who contributed part of the data.

Oil and Gas Developments in Southwestern Pennsylvania during 1944

By John T. Galey*

An intensified search for gas, because of the shortage in the area, led to the completion of 482 wells in southwestern Pennsylvania during 1944. This number was 27 more than the number in 1943, but 118 of the wells were nonproductive.

Shallow Development

Oil

The initial production of the 25 producers completed was slightly less than was obtained from four wells above last year's total. The largest well, 20 bbl., was found in the Big Injun (Miss.) sand in Morris township, Washington County, at a depth of 2085 ft. It is currently producing about 3 bbl. per day. Outside the main producing area, a well drilled in Nicholson township, Fayette County, obtained 15 bbl. per day from 1864 to 1866 ft. in the Gantz (U. Dev.) sand.

The Federal subsidy of 75¢ per barrel, effective Aug. 1, 1944, which increased to $3.40 the current pipe-line price in this area, seems to have been insufficient stimulus to materially increase drilling for oil, although more repressuring operations are contemplated.

Gas

The volume of initial open flow of gas developed is off slightly over 10 million cu. ft. from 36 more wells than were completed a year ago, and the average rock pressure of this new gas is more than 100 lb. less than that obtained a year ago.

Manuscript received at the office of the Institute April 24, 1945.

* Oil and Gas Operator, Pittsburgh, Pennsylvania.

Apparently the best find of this year was reported in Patton township, Allegheny County, where an initial volume of over 4 million cu. ft. was encountered in the Speechley (U. Dev.) sand at a depth of from 3293 to 3303 ft. The rock pressure there, 1190 lb. per sq. in., is nearly virgin. However, this area is fairly well delimited by dry holes and does not seem nearly so promising from the standpoint of reserves as the Armbrust area, which was discovered several years ago. In the Patton township locality another fair well with 1303 M cu. ft. open flow and 400 lb. per sq. in. rock pressure completed in the Hundred-Foot (U. Dev.) sand at a total depth of 2125 feet.

Armstrong County, as usual, leads in number of producing wells completed with lowest percentage of failures but ranks only fou th in volume of production developed. Only two wells here had more than one million cubic feet capacity, but the rock pressure was under 200 lb. per sq. inch.

In Fayette County, where the largest portion of new gas was found, activity appears to be shifting eastward. In Luzerne township, four producers having a total combined initial open flow in excess of 10 million cu. ft. were found in the Big Injun (Miss.) sand. The best well was found also in the same area in the Speechley sand (U. Dev.) at a depth of 3460 ft. This was a 2500-M cu. ft. well in Georges township.

Several wells of more than a million cubic feet capacity were found in Jackson, Washington, Wayne and Whitley townships, Greene County. None of these, however, was in a new pool.

The largest well of the year in Washington County was in Morris township. Here the Big Injun (Miss.) sand at a depth of 1945 ft. gave an initial of 3 million cu. ft. at 500 lb. per sq. in. Another large well, over 2 million cu. ft., was completed in one of the storage areas of Donegal township, and in North Strabane township a well having 1 million cu. ft. initial flow was found at a depth of 1580 feet.

TABLE 1.—*New Wells Drilled for Gas and Oil in Southwestern Pennsylvania during 1944*

County	Gas			Oil			Dry Holes		Total Number of Wells	Total Footage	Drilling as of Dec. 31, 1944
	Number of Wells	Footage	Open Flow, M Cu. Ft.	Number of Wells	Footage	Initial Production, Bbl.	Number	Footage			
Upper Devonian and Shallower Drilling											
Allegheny	26	73,244	8,202	2[b]	4,478	15	8	25,337	36	103,059	13
Armstrong	94	270,178	11,509	0	0	0	8	23,153	102	293,331	23
Beaver	1	1,163	114	2[b]	2,210	2	1	1,059	4	5,492	1
Butler	9	18,544	322	13	19,853	25[c]	9	13,483	31	51,880	6
Fayette	45	121,389	22,288	1	1,873	15	23	63,139	69	186,401	15
Greene	67	189,291	19,970	1	1,763	2	19	58,883	87	249,937	20
Indiana	20	62,861	1,374	0	0	0	12	33,556	32	96,427	5
Lawrence	1	748	20	0	0	0	2	1,483	3	2,231	0
Washington	37[a]	89,913	12,866	6	11,720	45	11	28,659	54	130,362	15
Westmoreland	37	120,766	8,119	0	0	0	23	68,770	60	189,536	9
Total	337	948,098	84,677	25	41,897	104	116	317,532	478	1,307,526	125
Lower Devonian and Deeper Drilling											
Summit Pool	2	14,752	1,940	0	0	0	0	0	2	14,752	1
Oriskany Wildcats	0	0	0	0	0	0	2	15,580	2	15,580	2
Total	339	963,850	86,617	25	41,897	104	118	333,112	482	1,337,858	128

[a] Includes 3 storage wells.
[b] Gas marketed with oil.
[c] Estimated.

Westmoreland County, which had the highest average in rock pressure of the completions, had only two large wells. One of these was found in the Fifth (U. Dev.) sand of Mt. Pleasant township and the other in the Murraysville (Miss.) sand of Hempfield township. The latter, however, had a closed-in pressure of less than one third of the county average.

Deep-sand Development

Two deep sand (L. Dev. or deeper) wildcat wells were completed during the year. One of these, in Harmony township, Beaver County, found a large head of salt water 13 ft. in the Oriskany sand. This was on a small southward plunging anticlinal nose, where formerly there was a good Hundred-Foot (U. Dev.) oil pool. The other, in Mercer township, Butler County, penetrated a sandstone, probably the Upper Cambrian, at a depth of 10,074 ft., and at 10,096 ft. found salt water in such volume that drilling operations had to be abandoned.

The Mercer township well is the deepest in the Appalachian area and is believed to be also the deepest well drilled entirely by cable tools in the world. The surprising total elapsed drilling time of 312 days was made on this operation.

Wildcat wells drilling at the year's end number only two. Of these, one is on the Chestnut Ridge anticline in Derry township, Westmoreland County, and has had great difficulty in drilling. The second

TABLE 2.—*Lower Devonian and Deeper Wildcat Operations in Southwestern Pennsylvania during* 1944

County	Township	Well	Elevation, Ft. above Sea Level	Depth, Ft.										Date Completed	Results
				Berea	Tully	Top Onondaga	Oriskany	Lockport	Medina	Top Trenton	Top Beekmantown Dolomite	Top Upper Cambrian Sandstone	Total		
Beaver	Harmony	Spang Chalfant No. 1	767	1,050–1,081	5,063–5,068	5,315	5,471						5,484	4- 7-44	Salt water from Oriskany rose 1500 ft. in 12 hr.
Butler	Mercer	Jessie C. Hockenberry No. 1	1,306	728–741	4,482–4,532	4,702	4,828–4,841	5,935–6,185	6,453–6,633	8,812	9,553	10,074	10,096	11-19-44	Show of gas 9,505–9,510 and 9,746–9,771. Salt water at 10,096 ft.
Washington	Cross Creek	J. E. McCullough No. 1	1,258												Drilling at 4,307 ft.
Westmoreland	Derry	Camilla F. Giffin No. 2	2,261												Drilling at 6,694 ft.

is being drilled apparently on a seismic high in Cross Creek township, Washington County.

TABLE 3.—*Summit (Fayette County) Gas Pool in* 1944

Township	Well	Elevation, Ft. above Sea Level	Depth, Ft.				Date Completed	Results
			Tully	Top Onondaga	Oriskany	Total		
Georges	Wm. R. Barton No. 4	2,370	6,425–6,505	6,988 T. c. 7,012[a]	7,340–7,497	7,510	1-27-44	1250 M cu. ft. initial from Onondaga chert
Georges	Wm. R. Barton No. 5	2,190	6,118–6,194	6,795 T. c. 6,823	7,073–7,209	7,242	12- 8-44	690 M cu. ft. initial Oriskany 7,073–7,076
South Union	Leo F. Heyn No. 1	2,316	6,021–6,100	6,572 T. c. 6,593	6,777–6,848	8,450	2-24-44	Deepened from 7,508 ft. No additional gas
South Union	Leo F. Heyn No. 3	2,314	5,845–5,915	6,393 T. c. 6,394	6,566–6,671	8,802	4-14-44	Deepened from 7,460 ft. No additional gas
Wharton	J. R. Thompson Heirs No. 1	2,316	6,930	7,464	7,638			Drilling at 7,746 ft.

[a] T. c. means top chert.

SUMMIT POOL

Two new gas wells were completed in the south end of the Summit pool, Georges township, Fayette County. One of them found gas in the Onondaga chert, and the second, which was nearly 100 ft. structurally higher, found the chert dry but obtained gas in the Oriskany sand.

Deepening of two wells at the north end of the pool was undertaken. Attempt was made to reach the Lockport dolomite in the discovery well, the Heyn No. 1, but the squeezing in of the salt beds caused the abandonment of the operation before the depth could be attained. The second well was deepened for the purpose of ascertaining the presence of gas in the top of the Silurian, in which some gas had been found in the Heyn No. 1 well. However, as the section thickened considerably over that expected, the Silurian gas-bearing horizon was not reached.

A new well east of the axis at the north end of the pool was drilling at the end of the year. The Onondaga was found dry and the Oriskany, which was encountered 860 ft. structurally lower than the Heyn No. 1 well, and had been penetrated for more than 100 ft., appears nonproductive.

ACKNOWLEDGMENT

The writer gratefully acknowledges the cooperation of Messrs. G. J. Donaldson, C. H. Feldmiller, C. R. Fettke, C. E. Loane, E. O. Schillhahn, and D. T. Secor, who have contributed to the data presented in this report.

Oil and Gas Developments in the Rocky Mountain Region in 1944

By R. M. Larsen,* Member A.I.M.E.

The Rocky Mountain region is defined with some variations for different purposes or by different organizations. For oil and gas development, Wyoming, Montana, Colorado, northwestern New Mexico, and Utah are included in the order of their apparent importance. Portions of adjoining states, such as North and South Dakota, Nebraska, Arizona, Nevada, and Idaho, are attributary to this region, but have little or no oil or gas production.

Nebraska and New Mexico are considered separately (see pp. 412 and 415), and most of the discussion in this report will be confined to Colorado, Montana, and Wyoming.

Utah has produced about 200,000 bbl. of oil from the San Juan and Virgin fields, which are isolated and shut in at present. The Clay Basin field in northeastern Utah produces natural gas and distillate, and the Farnham field in central Utah produces carbon dioxide gas. Other Utah areas of some interest are listed in Table 1.

The Cedar Creek (Baker-Glendive) field in southeastern Montana extends into North Dakota, but is listed under Montana.

The other states are in the main wildcat areas, and exploration in 1944 was at a minimum. However, geological and geophysical parties are reviewing them for further testing.

Oil production in Colorado, Montana and Wyoming was 459,000 bbl. more than in 1943. Increases of 713,000 bbl. in Colorado and 731,000 bbl. in Montana offset a loss of 985,000 bbl. in Wyoming. This was the first decline in Wyoming since 1938. Field production figures and state totals are given in Table 1.

Total drilling activities in these three states and Utah increased from 687 wells making 1,442,511 ft. of hole in 1943 to 916 wells making 2,245,803 ft. in 1944. Wildcat drilling increased from 163 wells making 331,193 ft. of hole in 1943 to 171 wells making 389,144 ft. in 1944. These figures include all drilling wells making footage, not starts or completions, and represent an all-time high in drilling.

The year 1944 witnessed the greatest concentration of seismograph activity that the region has had. The Rocky Mountain Oil Scouts Association reported that in 1943, the previous peak year, 91 crew months of work were performed; in 1944, the time was 254 crew months. About 67 per cent of the work was in Wyoming, 18 per cent in Montana, and 12 per cent in Colorado. Twenty-three blocks totaling 400,000 acres were reported assembled in Colorado, and 161 blocks totaling 4,000,000 acres in Wyoming. Information about other states was not given.

Fourteen unit agreements were approved by the Department of the Interior, as compared with 13 in 1943. The 1944 agreements were all in Wyoming. In five of the unit areas, oil or gas discoveries were made, four were dry, and five were drilling or pending. Oil companies find it advantageous to unitize blocks containing any proportion of public domain. Units for

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* U.S. Geological Survey, Casper, Wyoming.

TABLE 1.—*Oil and Gas Production in Rocky Mountain Region*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
	COLORADO										
1	Arikaree (Wray),* *Yuma*	1919	0	0	0	*x*	Non-Com.	0	6	0	0
2	Bell Rock,* *Moffat*	1930	0	0	0	*x*	0	0	1[2]	0	0
3	Berthoud, *Larimer*	1925	200	68,534	2,501	*x*	856	43	6	0	0
4	Black Canyon,* *Delta*	1917	0	0	0	550?	(Car. Dioxide)	0	4	0	0
5	Boulder, *Boulder*	1901	400	673,517	7,320	0	0	0	60?	0	0
6	Clark Lake, *Larimer*	1944	200	78,130	78,130	0	0	0	5	5	0
7	Craig,* *Moffat*	1932	0	0	0	*x*	*x*	3	3	0	0
8	DeBeque, *Mesa*	1902	0	Non-Com.	0	0	0	0	10?	0	0
9	Douglas Creek,* *Rio Blanco*	1943	0	0	0	*x*	0	0	1	0	0
10	Florence-Canon City, *Fremont*	1876	9,000?	13,868,337	44,262	0	0	0	535?	0	0
11	Fort Collins, *Larimer*	1924	520	2,334,058	33,542	0	0	0	17	1	0
12	Garcia,* *Las Animas*	1898	0	0	0	*x*	*x*	0	11	0	0
13	Garmesa,* *Garfield*	1925	0	0	0	*x*	50% (Car. Dioxide)	0	3	0	0
14	Greasewood, *Morgan and Weld*	1930	300	482,785	3,808	0	0	0	5	0	0
15	Hiawatha (East),* *Moffat*[1]	1926	320	771,706	99,529	2,160	23,689	2,450	15	0	0
16	Hiawatha (West),* *Moffat*	1929	0	0	0	1,440	7,837	708	5	0	0
17	Iles, *Moffat*	1925	600	10,556,957	456,326	0	0	0	34	0	0
18	Mancos Creek, *Montezuma*	1927	*x*	5,797	0	0	0	0	10	0	0
19	McCallum (North), (Walden) *Jackson.*	1926	1,400	165,861	58,938	0	(Car. Dioxide)	(with oil)	7	5	0
20	McCallum (South), *Jackson*	1928	40?	6,148	0	0	(Car. Dioxide)	0	2	0	0
21	Model Dome,* *Las Animas*	1927	0	0	0	2,485?	53?	0	5	0	0
22	Moffat, *Moffat*	1924	140	6,153,620	113,797	0	0	0	16	0	0
23	New Raymer,* *Weld*	1933	0	0	0	640?	0	0	1	0	0
24	Piceance Creek,* *Rio Blanco*	1930	0	0	0	3,835	0	0	3	0	0
25	Powder Wash,* *Moffat*	1931	360	169,610	51,715	1,840	4,610	1,450	8	1	0
26	Price (Gramps), *Archuleta*	1935	250	2,014,431?	225,000?	0	0	0	12?	0	0
27	Rangely (shallow), *Rio Blanco*	1902	2,760	1,873,805	289,733	0	0	0	67	7	2
28	Rangely (deep), *Rio Blanco*	1933	4,825	125,751	102,644	0	0	0	4	3	0
29	Red Mesa, *La Plata*	1924	*x*	5,355	1,260	0	0	0	*x*	*x*	*x*
30	Thornburg,* *Moffat, Rio Blanco*	1925	0	0	0	940	1,193	218	3	0	0
31	Tow Creek, *Routt*	1924	400	1,876,253	43,433	0	0	0	17	0	0
32	Wellington, *Larimer*	1923	1,600	5,131,768	63,784	0	0	0	31	0	0
33	White River, *Rio Blanco*	1917	0	0	0	640?	*x*	0	7	1	0
34	Wilson Creek, *Rio Blanco*	1938	2,300	3,568,083	1,400,268	0	*x*	*x*	20	8	0
35	Total Colorado			49,930,506	3,075,990		38,237	4,872	934	31	2

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Colorado side only.
[2] Abandoned after drilling.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil, Flowing	Oil, Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
								COLORADO						
1	0	0	0	400?	x			Niobrara, CreU	Sdy. Sh	1,472	20	D	Granite	5,595
2	0	0	0	1,050	x			Iles, CreU	S	2,845	15	Df	Sundance	9,084
3	0	1	2	1,310	x	39	−0.1	Pierre, etc. (gas) CreU Dakota (oil), CreU (Muddy)	Sdy. Sh S	3,750	x 12	A	Dakota	4,031
4	0	0	0	40?	x			Morrison? Entrada? Jur	S	200	50	A	Granite	565
5	0	2	0			39	−0.1	Pierre, CreU	S	2,500	var.	M, T	Dakota	6,145
6	0	5	0			38		Dakota, (Muddy), CreU	S	5,888	50	D?	Sundance	6,510
7	0	0	3	x	x			Iles, Morapos, CreU	S	2,733	50	AF	Morapos	3,880
8	0	0	0			38		Mesaverde, CreU	S	614	x	A	Mesaverde	3,542
9	0	0	0	1,380	1,380			Dakota-Lakota, Cre	S	4,326	74	AF	Basal Pen	8,558
10	0	76?	0			31	−0.1	Pierre, CreU	Sdy. Sh	1,000	x	M, T	Dakota	4,500
11	0	7	0			35	−0.1	Dakota, CreU	S	4,300	37	D	Lykins	5,206
12	0	0	0					Niobrara, CreU	Sdy. Sh	700	x	A	Fountain	2,500
13	0	0	0	825–1,100	x			Dakota, CreU Morrison, Jur Kayenta, Jur	S	2,857 3,132 3,755	21 34 116	D	Kayenta	3,871
14	0	1	0			42	−0.1	Dakota, CreU	S	6,650	25	Af	Morrison	7,042
15	0	6	5	1,100	375	37+	−0.1	Wasatch, Eoc	S	2,240	35	D	Mesaverde	7,577
16	0	0	3	852	x			Wasatch, Eoc	S	2,100	37	D	Pre-Wasatch	3,416
17	0	25	0			32	−0.1	Mancos, CreU Morrison, Jur Sundance, Jur	Sh Sd Sd	2,600 3,200 3,400	x 40 24	D	Nugget	4,166
18	0	0	0			34	0.2	Mancos, CreU	Sh	300	x	M, T	Dakota	1,280
19	6	0	0	2,400	2,342	46	−0.1	Dakota, CreU	S	4,960	95	Af	Morrison	5,388
20	0	0	0			42	−0.1	Dakota, CreU	S	4,875	20	A	Morrison	5,258
21	0	0	0	low	low			x	S	900	15	D	Fountain?	2,010
22	0	11	0			39	−0.1	Dakota, CreU Sundance, Jur	S S	3,994 4,597	80 103	D	Nugget	4,852
23	0	0	0	1,800	1,800			Dakota, CreU	S	6,692	6	M	Morrison	7,005
24	0	0	0	770	x			Green River-Wasatch, Eoc	S	2,661	20	D	Wasatch	5,130
25	3	1	3	912+	x	37+	−0.1	Wasatch, Eoc	S	2,150+	20	D, ML	Laramie	5,878
26	0	12	0			32	−0.1	Dakota, CreU	S	1,150	70	A	Morrison	1,752
27	0	32	0			41	−0.1	Mancos, CreU	Sh	530+	var.	D	Basal Pen	7,173
28	4	0	0			33	0.7	Weber, Pen	S	5,704	150	D	Basal Pen	7,173
29	x	x	x			42		Mesaverde, CreU Dakota, CreU	S S	700 3,500		D	x	x
30	0	0	3	725+	x			Dakota, CreU Nugget, Jur	S S	1,985 2,550	34 55	D	Nugget	3,110
31	0	9	0			37	−0.1	Mancos (Niobrara), CreU	Sh	2,580	var.	A	Gneiss	5,310
32	0	11	0			37	−0.1	Dakota, CreU	S	4,210	30	D	Lykins	5,000
33	0	0	0					Wasatch, Eoc	S	500+ 5,500+	15	D	Mesaverde	7,005
34	16	4	0			48	−0.1	Morrison, Sundance, Jur	S	6,600	50	Af	Sundance (Drg)	7,250
35	29	203	19											

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
	MONTANA										
36	Armells,* (Cone Butte), *Fergus*	1924	0	0	0	440	15	0	2	0	0
37	Bannatyne, *Teton*	1927	1,240	55,245	0	0	0	0	33	0	0
38	Bears Den, *Liberty*	1923	80	39,432	3,146	1,920	0	0	5	0	0
39	Berthelote, *Toole*	1930	40	10,932	495	0	0	0	2	0	0
40	Border, *Toole* (U. S. Side)	1929	480	881,980	21,088	0	0	0	26	0	0
41	Bow and Arrow,* *Toole*	1935	0	0	0	320	0	0	2	0	0
42	Bowdoin,* *Phillips and Valley*	1912	0	0	0	100,000	20,344	4,762	214	51	1
43	Bowes,* *Blaine*	1924	0	0	0	5,440	9,160	506	14	0	0
44	Boxelder,* *Blaine and Hill*	1916	0	0	0	1,480	4,732	456	7	0	0
45	Brady, *Pondera*	1943	Non-Com.	90	0	0	0	0	1	0	0
46	Cat Creek, *Garfield and Petroleum*	1920	800	14,987,171	113,145	0	0	0	208	0	0
47	Cedar Creek,* *Fallon and Wibaux.*	1914	Non-Com.	28,144	0	114,000	107,544	6,067	241	21	2
48	Clark Fork, *Carbon*	1944	*x*	1,189	1,189	0	0	0	1	1	0
49	Conrad-Midway, *Liberty*	1942	*x*	1,515	715	0	0	0	4	3	0
50	Cut Bank, *Glacier*	1926	41,680	42,341,143	5,442,736	70,840	119,783	14,926	1,041	98	0
51	Devil's Basin, *Musselshell*	1919	160	20,422	0	0	0	0	4	0	0
52	Devon,* *Toole*	1929	0	0	0	7,120	1,481	344	13	1	0
53	Dry Creek, *Carbon*	1929	1,280	2,163,753	92,998		11,171	1,046	15	1	0
54	Elk Basin, (light) *Carbon*[3]	1915	100	871,796	10,615		(see Wyoming)		22	0	0
55	Elk Basin, (black) *Carbon*[3]	1943	1,250	881,018	651,969				20	15	0
56	Flat Coulee, *Liberty*	1928	80	7,947	681	0	0	0	2	0	0
57	Frannie, *Carbon*[3]	1940	20	82,014	14,905	0	0	0	2	0	0
58	Fred and George Creek Nose,* *Toole*	1942	0	0	0	160	0	0	1	0	0
59	Gage, *Musselshell*	1943	640	102,963	102,963	0	0	0	6	5	0
60	Grandview,* *Liberty*	1930	0	0	0	160	0	0	1	0	0
61	Guinn,* *Phillips*	1931	0	0	0	160	0	0	3	0	0
62	Hardin,* *Big Horn*	1913	0	0	0	5,000	1,023	76	68	0	0
63	Havre,* *Hill*	1914	0	0	0	500	1,463	0	11	0	0
64	Haystack Butte,* *Liberty*	1941	0	0	0	640	267	95	2	0	0
65	Ingomar,* *Rosebud*	1943	0	0	0		(mainly nitrogen)		1	0	0
66	Kevin-Sunburst, *Toole*	1922	22,000	44,601,339	1,893,639	50,000	48,282	2,047	2,110	98	21
67	Kicking Horse,* *Toole*	1944	0	0	0	640	0	0	2	2	0
68	Kremlin,* *Hill*	1921	0	0	0	640	Non-Com.	0	2	0	0
69	Lake Basin, *Stillwater*	1922	200	441,481	13,255	*x*	6,125	0	19	0	0
70	Marias River,* *Toole*	1940	0	0	0	640	174	158	4	0	0
71	Mosser, *Yellowstone*	1936	80	5,588	0	0	0	0	5	0	0
72	Pondera, *Pondera*	1927	2,560	6,668,954	239,784	0	0	0	168	2	0
73	Price,* *Yellowstone*	1936	0	0	0	0	0	0	1	0	0
74	Pritchard Nose,* *Toole*	1915	0	0	0	160	0	0	1	0	0
75	Sherard,* *Choteau*	1923	0	0	0	160	0	0	2	0	0
76	Soap Creek, *Big Horn*	1921	535	128,753?	0	0	0	0	6	0	0
77	Thorpe, *Toole*	1941	400	15,443	15,443	0	0	0	3	1	0
78	Twin Rivers, *Glacier*	1942	640	4,680	2,462	0	0	0	2	0	0
79	Utopia, *Liberty*	1943	*x*	395	0	*x*	0	0	2	1	0
80	West Pondera, *Teton*	1939	0	0	0	160	0	0	2	0	0
81	Whitlash,* *Liberty*	1918	120	77,918	2,036	5,720	10,324	1,066	27	0	0
82	Winifred,* *Fergus*	1935	0	0	0	1,120	12	0	6	0	0
83	Total Montana			114,421,305	8,623,264		341,900	31,549	4,334	300	24

[3] Montana side only.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Reservoir Pressure, Lb. per Sq. In.: Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
								MONTANA						
36	0		0	400	x			Kootenai, CreL	S	1,238	14	D	Madison	3,569
37	0		0			26	1.8	Ellis, Jur	S	1,485	15	D	Madison	2,000
38	0	2	0	300?	x	40	0.8	Colorado (G.), CreU Kootenai (O.), CreL	S	1,600 2,200	14 85	N	Devonian	3,290
39	0	1	0			36	0.5	Kootenai, CreL	S	2,420	25	N	Madison	2,683
40	0	13	1			31	1.1	Kootenai, CreL	S	2,470	40	N	Madison	2,852
41	0	0	0	580	x			Kootenai, CreL	S	2,100	30	T	Madison	2,633
42	0	0	174	215–450	236			Colorado, CreU	Sdy. Sh	670	80	D	Quadrant	3,180
43	0	0	13	264	200			Eagle, CreU	S	655	100	Af	Devonian	4,700
44	0	0	7	425	300			Eagle, CreU	S	940	20	Af	Eagle	1,285
45	0	0	0			35	1.6	Kootenai, CreL	S	1,470	12		Madison	1,850
46	0	106	0			49	0.3	Colorado, CreU Kootenai, CreL	S S	1,160 1,340	50 40	A	Cambrian	5,705
47	0	0	179	210–450	96–325	28	0.9	Judith River CreU Eagle, CreU	S, Sdy. Sh	600–1,400	40–200	A	Pre-Cambrian	9,680
48	1	0	0			45	−0.1	Frontier, CreU	S	6,445	x	x	Frontier	6,531
49	0	4	0			42	1.0	Kootenai, CreL	S	1,725	20	M?	Devonian	3,695
50	0	900	88	710	595	37	1.0	Kootenai, CreL	S	2,850	20	MC	Madison	3,238
51	0	0	0			22	1.5	Heath?, MisU	var.	1,160	10	D	Madison	2,505
52	0	0	7	135	112			Colorado, CreU	S	780	15	M	Madison	2,190
53	1	5	4	1,250	700	52	−0.1	Frontier, CreU Cloverly, CreL Morrison, Jur	S	4,100–5,900	50	Df	Cambrian	8,882
54	0	19	0			43	−0.1	Frontier, CreU	S	1,700	40	A	Amsden	5,853
55	6	14	0			30	1.7	Tensleep, Pen	S	5,700	100	A	Amsden	5,853
56	0	2	0			32	1.0	Kootenai, CreL	S	2,600	75	D	Madison	3,015
57	0	2	0			28	2.4	Tensleep, Pen	S	3,465	30	Df	Tensleep	3,561
58	0	0	0	200	x			Colorado, CreU	S	1,510	15	N	Colorado	1,552
59	1	3	0			33	0.8	Amsden, Pen	D, S	5,965	5	D	Madison	7,495
60	0	0	0					Kootenai, CreL	S	2,343	5	N	Madison	2,588
61	0	0	0	198				Eagle, CreU	S	435	25	D	Madison	2,035
62	0	0	58	140	80			Frontier, CreU	S	735	30	ML	Tensleep	4,195
63	0	0	2	540	x			Eagle, CreU	S	975	85	Af	Eagle	1,592
64	0	0	2	404	x			Colorado, CreU	S	1,940	80	D	Madison	2,923
65	0	0	0	1,000	x			Amsden, Pen	D, S	3,800	195	Af	Madison	5,910
66	0	1,317	185	330	x			Kootenai, CreL Ellis-Madison, Jur, MisL	S, S, L	1,100 1,200	15 10	D	Cambrian	4,690
67	0	0	0	580	x			Kootenai-Ellis, CreL, Jur	S	1,475	var.	D	Madison	2,095
68	0	0	1					Eagle, CreU	S	1,000	25	Af	Madison	3,665
69	0	2	0	240	x			Eagle, Frontier (G), CreU Cloverly (O), CreL	S S	1,310, 3,060 3,960	var.	A	Madison	6,002
70	0	0	4	194	x			Colorado, CreU	S	753	12	ML	Ellis	1,982
71	0	0	0			22	1.6	Cloverly, CreL	S	1,000	10	DF	Madison	2,568
72	0	154	1			32	1.8	Madison, MisL	L	2,000	20	T	Pre-Cambrian	5,234
73	0	0	0					Cloverly, CreL	S	961	x	D	Madison	2,225
74	0	0	0					Colorado, CreU	Sdy. Sh	1,665	x	N	Madison	2,840
75	0	0	0	570	x			Eagle, CreU	S	1,735	25	AF	Colorado	2,983
76	0	0	0					Amsden, Pen	S	1,650	x	D	Madison	2,260
77	0	2	0					Sunburst, CreL Ellis, Jur	S S	1,850 2,060	x	M	Madison	2,119
78	0	2	0					Madison, MisL	L	3,900	35	D?	Madison	4,084
79	0	0	0					Madison, MisL	L	2,450	5	N	Madison	2,610
80	0	0	0					Colorado, CreU	S	1,560	5	N	Madison	2,320
81	0	5	17					Colorado, CreU Kootenai, CreL	S S	1,600 2,000	var.	D	Cambrian	4,068
82	0	0	0	80	x			Eagle, CreU	S	390	170	Af	Kootenai	3,305
83	9	2,553	743											

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
	UTAH										
84	Ashley Valley,* *Uintah*	1925	0	0	0	200	536	0	2	0	0
85	Boundary Butte,* *San Juan*	1924	0	0	0	*x*	0	0	1[2]	0	0
86	Cisco,* *Grand*	1924	0	0	0		3,138	0	10	0	0
87	Clay Basin,* *Daggett*	1927	0	134,371[4]	21,557[4]	4,240	33,182[4]	6,202[4]	9	0	0
88	Farnham,* (CO_2) *Carbon*	1924	0	0	0	1,360	981	167	1	0	0
89	Harley Dome,* *Grand*	1925	0	0	0	300	0	0	2	0	2
90	San Juan, (Mexican Hat) *San Juan*	1908	*x*	14,000?	0	0	0	0	*x*	0	0
91	South Last Chance,* *Emery*	1934	0	0	0	*x*	0	0	1	0	0
92	Virgin, *Washington*	1907	680	183,310	0	0	0	0	53	0	0
93	Woodside,* *Emery*	1924	0	0	0	1,500	0	0	1[2]	0	0
94	Total Utah			331,681	21,557		37,837	6,369	80	0	2
	WYOMING										
95	Alkali Butte,* *Fremont*	1920	600	10,617	0	600	0	0	4	0	0
96	Allen Lake,* *Carbon*	1933	0	0	0	150	1,749	−2	3	0	0
97	Ant Hills, *Niobrara*	1927	0	6,556	0	0	0	0	1	0	0
98	Aspen, *Uinta*	1903–28	0	Non-Com.	0	0	0	0	3	0	0
99	Badger Basin, *Park*	1930	1,000	578,000	57,814	0	0	0	5	0	0
100	Bailey Dome, *Carbon*	1944	140	0	0	0	0	0	1	1	0
101	Baxter Basin (Middle),* *Sweetwater*	1938	0	0	0	1,680	2,235	550	7	0	0
102	Baxter Basin (North),* *Sweetwater*	1926	0	625	0	8,500	22,758	1,800	7	0	0
103	Baxter Basin (South),* *Sweetwater*	1922	0	0	0	8,800	55,522	7,100	35	2	0
104	Beaver Creek,* *Fremont*	1938	0	0	0	1,603	88	88	1	0	0
105	Bell Springs,* *Carbon*	1924–44	0	0	0	320	0	0	2	1	0
106	Big Hollow, *Albany*	1938	80	5,789	624	0	0	0	4	2	0
107	Big Medicine Bow, *Carbon*	1935	705	4,195,573	211,010		10,564?	179	12	0	1
108	Big Muddy, *Converse*	1916	2,640	28,705,472	506,229	0	0	0	249	3	0
109	Big Piney,* *Sublette*	1938	0	0	0	*x*	0	0	6	1	0
110	Big Polecat,* *Park*	1916	0	0	0	800	753	154	3	0	0
111	Big Sand Draw, *Fremont*	1918–1944	320?	0	0	1,960	82,706	6,456	16	1	0
112	Billy Creek,* *Johnson*	1923	0	0	0	710	3,182	0	9	0	0
113	Bison Basin, *Fremont*	1929	*x*	0	0	*x*	0	0	3	1	0
114	Black Mountain, *Hot Springs, Washakie*	1922	615	381,142	9,235	0	0	0	6	0	0
115	Bolton Creek, *Natrona*	1920	120	43,335	0	0	0	0	12	0	0
116	Boone Dome, *Natrona*	1923	0	0	0	400	1,245	−2	4	0	0
117	Brenning Basin (Douglas), *Converse*	1902	40	7,052	0	0	0	0	5?	0	0
118	Bunker Hill,* *Carbon*	1937	0	0	0	680	1,222	259	4	0	0
119	Byron, *Big Horn*	1918–30	1,650	10,287,791	1,999,226	600	4,181	188	42	8	0
120	Canyon Creek,* *Sweetwater*	1941	0	0	0	80	0	0	1	0	0
121	Circle Ridge, *Fremont*	1923	210	586,744	270,860	0	0	0	12	0	0
122	Cole Creek, *Natrona, Converse*	1938	1,652	1,815,060	517,915	0	0	0	35	5	0

[4] Distillate produced with gas.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944 — Oil — Flowing	Wells Producing[g] Dec. 1944 — Oil — Artificial Lift	Wells Producing[g] Dec. 1944 — Gas	Reservoir Pressure, Lb. per Sq. In. — Initial	Reservoir Pressure, Lb. per Sq. In. — Avg./End 1944	Character of Oil[i] — Gravity A.P.I. at 60°F.	Character of Oil[i] — Sulphur, Per Cent	Producing Formation — Name and Age[j]	Producing Formation — Character[k]	Producing Formation — Depth to Top of Producing Zone, Ft.[m]	Producing Formation — Productive Thickness, Avg. Ft.,[n] Net	Producing Formation — Structure[o]	Deepest Zone Tested[p] to End of 1944 — Name	Deepest Zone Tested[p] to End of 1944 — Depth of Hole, Ft.
								UTAH						
84	0	0	0					Morrison, Jur	S	1,663	8	Df	Nugget	2,720
85	0	0	0					Hermosa, Pen	L	4,500±	var.	A	Mississippian?	5,612
86	0	0	1					Dakota, CreU Morrison, Jur	S S	1,915 2,044	15 12	D	Moenkopi-granite	4,744
87	0	0	7	2,160	x			Frontier,Dakota, CreU	S	5,747	55	D	Nugget	6,799
88	0	0	1	900?	x			Moenkopi, Tri	S	3,086	20	Af	Moenkopi	3,235
89	0	0	0	157	x			Morrison, Entrada, Jur	S	564+	120	D	Wingate	1,675
90	0	0	0			39	.2	Rico, Hermosa, Per-Pen	S	250+		S	Granite	3,633
91	0	0	0	480	410			Moenkopi, Tri	S	2,724	56	D	Coconino	3,168
92	0	0	0			30	.8	Moenkopi, Tri	L	500	5	M	Supai	2,195
93	0	0	0					Coconino, Per	S	3,120	45	D	Coconino	3,375
94	0	0	9											
								WYOMING						
95	0	0	0	600–1,880	580–1,880	34	−0.1	Muddy, (Oil) CreU Cloverly, (Gas) CreL Morrison, (Gas) Jur	S	3,960 4,381 4,571	27 13 25	AF	Chugwater	5,459
96	0	0	0	900				Sundance, Jur	S	2,000	80	D	Tensleep	4,362
97	0	0	0			29	+0.1	Newcastle (Muddy), CreU	S	3,945	7	D	Pahasapa	6,825
98	0	0	0			26	−0.3	Bear River, CreU	S	822	15	MU	Bear River?	5,092
99	3	0	0			48	−0.1	Frontier, CreU	S	8,190	50	D	Morrison	10,121
100	1	0	0			34	−0.1	Sundance, Jur	S	5,100	45	D	Sundance	5,234
101	0	0	5	970	x			Frontier,Dakota, CreU	S	1,900 2,470	47 12	AF	Pennsylvanian	6,302
102	0	0	5	1,010–1,120	x	41	0.6	Dakota, CreU Sundance, Jur	S S	2,950 3,388	25 29	AF	Tensleep	6,527
103	0	0	27	752–795	x			Frontier, CreU Dakota, CreU	S S	2,345 3,083	26 27	AF	Madison	7,172
104	0	0	1	3,450	3,450			Morrison? Jur	S	8,230	25	D	Sundance	8,920
105	0	0	0	860–1,100	860–1,100			Cloverly (abd), CreL Sundance, Jur	S S	1,850 2,270	40 60	D	Deadwood	4,466
106	0	1	0			19	0.1	Muddy, CreU	S	827	21	D	Tensleep	2,583
107	4	1	0	2,510	x	63	−0.1	Sundance, Jur	S	5,250	100	D	Granite	7,847
108	0	137	0			34	0.1	Niobrara, Shannon, Frontier, CreU Cloverly, CreL	Sh, S S	1,000–3,000 4,335	88 40	D	Madison	6,597
109	0	0	0	400±	400±			Wasatch, Eoc	S	910	x	x	Wasatch	3,056
110	0	0	2	700	495–			Frontier, CreU	S	2,232	40	Df	Mowry	3,343
111	0	0	13	1,059–1,880	568–970	34	2.1	Frontier Gas, CreU Lakota Gas, CreL Morrison Gas, Jur Tensleep Oil, Pen	S S S S	2,215–4,284 7,310	var.	A	Tensleep	7,593
112	0	0	0	1,150	262			Frontier, CreU	S	3,200	12		Big Horn	7,775
113	0	0	0	42	x	17	0.4	Frontier, CreU	S	977	12	D	Tensleep	4,923
114	0	0	0			26	2.8	Embar-Tensleep, Per-Pen	L, S	2,918	90	D Af	Madison	3,832
115	0	0	0			22	2.3	Sundance, Jur Embar, Per	S L	1,090 2,040	20 20	D	Tensleep	2,530
116	0	0	1	760	x			Steele, CreU	S	1,540	20	A	Niobrara	5,192
117	0	0	0			35	+0.4	White River, Olig	S	360	10	MU	Dakota	3,030
118	0	0	4					Steele (Shannon), CreU	S	1,325	25	Df	Madison	9,392
119	0	37	2					Frontier (Gas), CreU Embar-Tensleep (Oil) Per-Pen	S L, S	2,163 5,020	30 80	Df	Amsden	6,060
120	0	0	0	1,250	x			Wasatch, Eoc	S	2,688	22	D	Pre-Wasatch	3,955
121	0	11	0			23	2.8	Embar-Tensleep, Per-Pen	L, S	185	42	D	Tensleep	803
122	0	33	0			36	0.1	Steele (Shannon), CreU Cloverly (Dak.-Lak.), CreL	S S	4,550 8,000	17 30	D	Chugwater	8,707

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
123	Cooper Cove, *Carbon*	1944	100	13,137	13,137	0	0	0	2	2	0
124	Crooks Gap, *Fremont*	1925–44	200	2,365	2,365	0	0	0	1	1	0
125	Crystal Creek, *Big Horn*	1919	0	Non-Com.	0	0	0	0	1	0	0
126	Dallas, *Fremont*	1884	160	3,171,095	152,558	0	0	0	38	0	0
127	Derby, *Fremont*	1921	120	584,335	15,530	0	0	0	16	0	0
128	Dewey, *Weston*	1936	5?	8,925	353	0	0	0	1	0	0
129	Dry Piney, *Sublette*	1918	*x*	Non-Com.	0	*x*	0	0	2	0	0
130	Dutton Creek,* *Carbon*	1927	180	333,878	13,705	625	1,242	81	8	0	0
131	East Allen Lake,* *Carbon*	1937	0	0	0	350	3,200	792	3	0	0
132	Elk Basin (light), *Park*[5]	1915	750	10,776,842	118,044	750	38,493	1,890	139	0	0
133	Elk Basin (black), *Park*[5]	1942	4,600	4,716,753	2,718,922	0	(with oil)		67	47	0
134	Enos Creek,* *Hot Springs*	1923	0	0	0	500	0	0	1	0	0
135	Ferris (East and West), *Carbon*	1919	420	281,690	0	*x*	*x*	18	21	0	0
136	Fourbear, *Park*	1928	400	6,456	2,320	0	0	0	2	1	0
137	Frannie, *Park*[5]	1928	700	8,660,990	1,077,298	0	0	0	33	4	0
138	Garland, *Big Horn and Park*	1906–1930	2,000	8,129,414	550,053	640	60,189?	3,160	76	12	0
139	Gebo, *Hot Springs*	1943	280	154,461	154,461	0	0	0	4	3	0
140	Golden Eagle, *Hot Springs*	1921–44	160	0	0	160	2,546	0	3	1	0
141	Gooseberry, *Park*	1937	620	19,331	0	0	0	0	1	0	0
142	G. P. Dome, *Carbon*	1920	60	181,129	963	0	0	0	3	0	0
143	Grass Creek (light), *Hot Springs*	1914	1,480	28,236,852	531,392	0	*x*	21	323	0	0
144	Grass Creek (black), *Hot Springs*	1921	2,000	5,347,727	460,693	0	0	0	22	5	0
145	Greybull, *Big Horn*	1907	300	280,724	487	0	0	0	80	0	0
146	Half Moon, *Park*	1944	200	290	290	0	0	0	1	1	0
147	Hamilton Dome, *Hot Springs*	1918	1,000	7,090,042	441,151	*x*	74	23	35	0	0
148	Hatfield,* *Carbon*	1923	0	0	0	880	5,352	41	2	0	0
149	Hay Creek,* *Campbell*	1934	0	0	0	*x*	local fuel		2	0	0
150	Hiawatha (East),* *Sweetwater*	1927	0	0	0	1,980	12,272	632	4	0	0
151	Hidden Dome, *Washakie*	1918–32	150	359,339	10,301		22,148	0	25	0	1
152	Horne,* *Carbon*	1939	0	0	0	80	0	0	1	0	0
153	Horse Creek, *Laramie*	1942	275	23,197	5,043	0	0	0	2	0	0
154	Iron Creek, *Natrona*	1917	80	52,571	5,261	0	0	0	7	0	0
155	Kirby Creek (light), *Hot Springs*	1918	60	72,442	6,403	0	0	0	8	0	1
156	Kirby Creek (black), *Hot Springs*	1944	80	447	447	0	0	0	1	1	0
157	La Barge, *Lincoln and Sublette*	1924	820	9,426,628	585,648	*x*	(fuel and recycling)	112	161	0	0
158	La Barge (North), *Sublette*	1927	360	58,982	10,516		fuel		7	1	0
159	Lake Creek, *Hot Springs*	1925	100	13,343	0	0	0	0	1	0	0
160	Lamb,* *Big Horn*	1913	0	0	0	Abd.	1,819	0	8	0	0

[5] Wyoming side only.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
123	0	1	0			33	0.3	Cloverly (Dakota), CreL	S	4,850	40	A	Jelm	5,373
124	1	0	0			37	−0.3	Cloverly (Lakota), CreL	S	5,232	20	Af	Cloverly	5,315
125	0	0	0			17	4.0	Tensleep, Pen	S	724	20	Af	Madison	1,805
126	0	26	0			21	2.3	Embar-Tensleep, Per-Pen	L, S	700	65	D	Tensleep	2,005
127	0	10	0			21	2.7	Embar-Tensleep, Per-Pen	L, S	800	40	D	Amsden	2,435
128	0	1	0			31	1.2	Minnelusa, Pen	S	2,301	4	MF	Minnelusa	2,666
129	0	0	0			40	+0.1	Hilliard, CreU	S	750	10	A	Bear River	8,194
130	0	3	5	430		34	−0.3	Steele (G), Muddy (O), CreU	S	1,600(C) 4,860 (O)	30	D	Sundance	5,466
131	0	0	3	1,000				Sundance, Jur	S	2,044	50	D	Chugwater	2,400
132	0	79	6			45	−0.1	Frontier(O), CreU Cloverly (G), CreL	S S	1,200 2,350	50 30	Af	See below	
133	59?	1?	0			30	1.7	Tensleep, Pen	S	3,945+	100	Af	Madison	6,808
134	0	0	0	850				Frontier, CreU	S	2,835	x	A	Cloverly	3,992
135	0	0	2			37	0.2	Mowry, Thermopolis (O), CreU Cloverly, Sundance, (G) CreL, Jur	S S	1,400− 2,775	var.	D	Tensleep	5,057
136	0	0	0			14	3.9	Tensleep, Pen	S	2,880	20	A	Amsden	3,350
137	1	27	0			28	2.4	Tensleep, Pen Madison, Mis	S L	2,565 2,925	60 50	D	Madison	3,343
138	0	25	7			23	2.9	Frontier (O & G), CreU Cloverly (G), CreL Embar-Tensleep (O & G), Per-Pen Madison (O), MisL	S S S, L L	500 1,750 3,500 4,250	30 30 100 50	D	Three Forks	4,424
139	3	0	0			28	2.0	Embar-Tensleep, Per-Pen	L, S	4,535	275	D	Tensleep	5,309
140	0	0	0					Mesaverde (Abd. G), CreU Muddy, Greybull (O & G), Cre	S S	2,980 6,720	x 85	D	Morrison	7,379
141	0	0	0			22	2.0	Embar-Tensleep, Per-Pen	L, S	5,670	100	D	Big Horn	6,965
142	0	2	0			37	0.2	Niobrara, CreU	S	3,000	60	N	Frontier	5,465
143	0	266	0			45	0.1	Frontier, CreU	S	500+	80	D	See below	
144	0	19	0			23	2.5	Chugwater, Tri Embar-Tensleep,Per-Pen	S L, S	3,100 3,565+	30 80	D	Amsden	4,336
145	0	0	0			48	0.1	Cloverly, CreL	S	800+	20	Df	Tensleep	2,950
146	0	0	0			15	4.0	Embar, Per	L	3,426	30	Af	Madison	4,265
147	0	25	1			16–23	3.0	Chugwater, Tri Embar-Tensleep,Per-Pen	S L, S	1,900 2,300+	70	Df	Tensleep	2,700
148	0	0	1					Muddy, CreU	S	3,750	12	Df	Chugwater	4,676
149	0	0	1	80?				Fort Union? Pale	S	395	20	T	Fort Union?	415
150	0	0	4	995				Wasatch, Eoc	S	2,240+	30	D	Wasatch	3,845
151	0	10	0	725	−60	43	0.2	Frontier, CreU	S	1,170+	25	A	Morrison	2,790
152	0	0	0	260				Mowry, CreU	Sdy. Sh	750	55	A	Tensleep	2,540
153	0	2	0			31		Muddy, CreU Cloverly, CreL	S S	5,300 5,450	14 20	Af	Casper	7,457
154	0	6	0			29	0.1	Cloverly, CreL	S	720	30	D	Tensleep	3,437
155	0	6	0			41	0.1	Frontier, CreU	S	367	10	A	See below	
156	0	1	0			21	3.3	Embar, Per	L	3,334	84	A	Madison	4,427
157	0	142	3			29	0.1	Wasatch, Eoc	S	650+	150	A	Hilliard	4,886
158	0	5	1			42	−0.1	Wasatch(?), Eoc	S	2,000	50	x	Aspen	8,005
159	0	0	0			22	3.2	Embar, Per	L	3,700	20	A	Tensleep	4,400
160	0	0	0					Frontier Muddy, CreU	S	550 1,370	25 30	D	Muddy	1,397

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
161	Lance Creek, *Niobrara*	1918–1937	4,745	62,775,727	6,503,201	0	(fuel and repressuring)	2,608	274	8	2
162	Lance Creek (East), *Niobrara*	1919–37	530	277,476	31,446	100	0	0	3	1	0
163	Lander (Hudson), *Fremont*	1909–26	300	2,506,903	89,149	0	0	0	37	0	0
164	Little Buck Creek, *Niobrara*	1944	80	18,616	18,616	0	0	0	1	1	0
165	Little Buffalo Basin,* *Park, Hot Springs*	1914–43	1,400	3,837	3,837	4,806	28,985	2,292	14	4	0
166	Little Grass Creek,* *Hot Springs*	1917	0	0	0	530	1,652	2	3	1	0
167	Little Polecat,* *Park*	1922	0	0	0	500	1,668	96	1	0	0
168	Lost Soldier (shallow), *Sweetwater*	1916	480	20,867,429	255,302	0	0	0	126	0	2
169	Lost Soldier (deep), *Sweetwater*	1930	1,300	8,008,107	982,764	0	0	0	21	7	0
170	Mahoney, *Carbon*	1925–30	400	1,718,929	284,642	1,120	58,286	143	26	0	0
171	Mahoney (East), *Carbon*	1924–40	80	100,700	3,271	1,600	35,202	460	16	0	2
172	Maverick Springs, *Fremont*	1917	1,350	2,399,995	474,072	0	0	0	44	5	0
173	Midway, *Natrona*	1931	280	129,603	0	0	0	0	3	0	0
174	Moorcroft, *Crook*	1887	0	800	0	0	0	0	4	0	0
175	Mule Creek (East), *Niobrara*	1919	290	1,990,323	105,388	0	0	0	41	0	0
176	Mule Creek (West), *Niobrara*	1927	40	106,704	2,954	0	0	0	23	0	0
177	Mush Creek, *Weston*	1943	*x*	8,318	8,318	0	0	0	1	1	0
178	Muskrat,* *Fremont*	1928	0	0	0	720	19,621	1,960	5	0	0
179	Newcastle, *Weston*	1941	*x*	250	0	0	0	0	1	0	0
180	North Casper Creek, *Natrona*	1925	*x*	9,384	0	0	0	0	3	0	0
181	North Sunshine, *Park*	1928	400	3,016	0	0	0	0	1	0	0
182	Notches, *Natrona*	1923	420	446,661	117,804	0	0	0	6	1	0
183	Oil Springs,* *Carbon*	1938	0	0	0	110	3,173	820	3	0	0
184	Oregon Basin (North), *Park*	1912–27	2,760	13,335,074	1,974,418	450	5,540	454	63	16	0
185	Oregon Basin (South), *Park*	1912–27	4,340	16,379,311	2,417,082		(Small, see North)	0	82	12	
186	Osage, *Weston*	1919	6,840	5,513,292	164,271	0	(casinghead only)		623	0	0
187	Pedro, *Weston*	1924		(under Osage)		0	0	0	22	0	0
188	Pilot Butte (light), *Fremont*	1916	380	611,787	8,317	320	Shut-in	0	37	0	-0
189	Pilot Butte, (black), *Fremont*	1942	160	995,820	361,929	0	0	0	5	0	0
190	Pine Mountain, *Natrona*	1914	*x*	6,354	0	*x*	0	0	7	0	0
191	Pitchfork, *Park*	1930	400	66,255	64,167	0	0	0	3	2	0
192	Plunkett, *Fremont*	1909	40	17,832	243	0	0	0	16?	0	0
193	Poison Spider, *Natrona*	1917	480	1,141,618	45,606	*x*	*x*	0	28	1	0
194	Powder River,* *Natrona*	1930–44	0	0	0	300	39	39	3	1	0
195	Quealy, *Albany*	1934	210	1,695,590	187,447	0	0	0	17	0	0
196	Red Springs, *Hot Springs*	1919–42	320	7,034	0	0	0	0	2	0	0
197	Rex Lake, *Albany*	1923	260	288,085	11,739	0	0	0	7	0	0

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Avg./End 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
161	44	138	1			42	0.1	"Dakota," CreL Sundance, Jur Minnelusa (Converse, Leo), Pen	S S S	3,200 3,800 5,200	25 60 30	D	Deadwood	6,256
162	0	2	1			44	0.1	"Dakota," CreL	S	3,900	30	A	Pahasapa	6,434
163	0	13	0			23	3.0	Embar-Tensleep, Per-Pen	L, S	1,000+	65, 40	A	Tensleep	2,148
164	1	0	0			41	−0.1	"Dakota," CreL	S	3,800	50	D	Spearfish	4,964
165	0	3	6			20	3.4	Frontier (G), CreU Embar (O), Per Tensleep (O), Pen	S L S	1,135 4,295 4,464	var. 30 200	D	Madison	5,944
166	0	0	1					Frontier, Muddy, CreU	S	2,562, 3,580	100	D	Madison	6,632
167	0	0	1					Frontier, CreU	S	4,200	50	D	Tensleep	6,929
168	2	26	17			31	0.2	Frontier, CreU Cloverly, CreL Sundance, Jur	S S S	550 1,550 1,900	20 60 80	D	See below	
169	15	5	0			35	1.0	Tensleep, Pen	S	3,900+	325	D	Amsden	6,475
170	0	9	4	950	x			Cloverly (G), CreL Sundance (G), Jur Tensleep (O), Pen	S S S	2,300 2,700 4,300	30 35 60	A	Cambrian	5,366
171	0	1	10					Cloverly (G), CreL Sundance (G), Jur Tensleep (O), Pen	S S S	2,410 2,750 4,300	30 40 25	A	Madison	5,344
172	0	32	0			22	3.0	Embar, Per	L	1,090+	15	D	Big Horn	3,228
173	0	0	0			31	0.1	Frontier, Muddy? CreU	S	5,150+	20	D	Chugwater	6,689
174	0	0	0			22	x	Newcastle, CreU	S	725		M	Deadwood	3,511
175	0	41	0			31	0.1	Lakota, CreL Minnelusa, Pen	S S, L	1,285 3,160	31 23	D	Minnelusa	3,837
176	0	20	0			34	0.1	Dakota group, Cre Minnelusa, Pen	S Sdy. Sh	240+ 2,665	13 5	D	Pahasapa(?)	3,047
177	0	1	0			38	−0.1	Newcastle, CreU	S	3,850	1	x	Newcastle	3,852
178	0	0	4					Frontier, CreU Cloverly, CreL	S S	4,140 5,400	25 25	A	Madison	8,112
179	0	0	0			22	0.1	Newcastle, CreU	S	560	17	x	Graneros	620
180	0	0	0			22	2.8	Tensleep, Pen	S	3,200	4	D	Tensleep	3,400
181	0	0	0			15	3.7	Tensleep, Pen	S	3,480	x	D	Amsden	3,780
182	0	5	0			22	1.6	Tensleep, Pen	S	2,740	35	D	Tensleep	2,993
183	0	0	2	1,100	x			Sundance, Jur	S	2,200	120	Af	Chugwater	2,717
184	8	53	1			21	3.2	Frontier (Abd), CreU Cloverly (G), CreL Embar-Tensleep, Per, Pen	S S L, S	1,100 1,300 2,900+	10 65	D	Madison	4,502
185	8	64	1			21	3.2	Cloverly (G), Embar-Tensleep, Per, Pen Madison, MisL	S L, S L	1,300 2,900+ 4,500	10 70	D	Three Forks	4,663
186	0	322	0			39	−0.1	Graneros, CreU	Sh, S	200–3,300	10	M, T	Minnelusa	2,592
187	0	8	0			30	0.2	Graneros, CreU	Sh, S	200+	10	M, T	Niobrara?	840
188	0	18	0			38	−0.1	Cody (O), Muddy (G), CreU	S	500–3,500	30	Df	See below	
189	0	4	0			26	2.4	Embar-Tensleep, Per, Pen	L, S	6,250	160	Df	Amsden	6,775
190	0	0	0			19	0.2	Embar-Tensleep, Per, Pen	L, S	1,800	5	D	Deadwood	3,127
191	0	2	0			18	3.7	Embar-Tensleep, Per, Pen	L, S	3,350	100	A	Amsden	3,903
192	0	0	0			41	−0.1	Mowry, CreU	Sh	450	10	N	Morrison	1,916
193	0	21	0			22	2.7	Sundance, Jur	S	1,200	114	D	Granite	4,119
194	0	0	1					Frontier, CreU Sundance, Jur	S S	900 2,490	130 44	D	Madison	4,889
195	6	9	0			34	0.2	Muddy, CreU Cloverly, CreL Sundance, Jur	S S S	3,225 3,300 3,375	40 82 81	D	Chugwater	4,010
196	0	0	0			11	4.4	Madison, MisL	L	900	80−	D	Madison	1,095
197	0	2	0			32	−0.1	Muddy, Dakota, CreU	S	3,700	20	D	Chugwater	4,436

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
198	Rock Creek, *Carbon*	1918	1,740	23,570,421	923,569	0	(Field Use, Sales, Recycling)	91	81	0	0
199	Rocky Ford, *Crook*	1909	120	Non-Com.	0	0	0	0	4	0	0
200	Sage Creek, *Fremont*	1916	40	2,000	0	0	0	0	3	0	0
201	Salt Creek (light), *Natrona*	1906	21,450	310,726,454	4,295,890		(Field Use, Sales, Recycling)	3,405	2,211	0	18
202	Salt Creek (black), *Natrona*	1930	1,000	2,115,180	475,642	0	0	0	13	1	0
203	Shannon, *Natrona*	1889	55	53,441	0	0	0	0	43	0	0
204	Shawnee, *Converse*	1936	20	1,337	377	*x*	Non-Com.	0	10	1	0
205	Sheep Creek, *Fremont*	1935	160	6,064	0	0	0	0	2	0	0
206	Sheldon,* *Fremont*	1925	0	0	0	100	0	0	1[2]	0	0
207	Sherard,* *Carbon*	1941	0	0	0	180	424	64	3	0	2
208	Shoshone, *Park*	1910–29	160	151,047	20,905	0	0	0	5	0	0
209	Simpson Ridge, *Carbon*	1923	160	213,633	5,148	0	0	0	8	0	0
210	South Casper Creek, *Natrona*	1919	600	3,441,375	183,880	0	0	0	31	0	0
211	South Spring Creek, *Park*	1929	760	39,622	0	0	0	0	1	0	0
212	South Sunshine, *Park*	1926	200	7,715	0	0	0	0	2	1	0
213	Spence, *Big Horn*	1928–44	80	3,956	3,956	0	0	0	5	3	0
214	Spindletop, *Natrona*	1922	80	45,380	7,670	0	0	0	6	1	0
215	Spring Valley, *Uinta*	1900	220	199,677	328	0	0	0	30?	0	1
216	Steamboat Butte (light), *Fremont*	1944	120	2,182	2,182	*x*	0	0	1	1	0
217	Steamboat Butte (black), *Fremont*	1943–4	1,100	820,024	601,041	0	0	0	6	3	0
218	Sulphur Creek, *Uinta*	1943	80	1,305	1,005	0	0	0	3	2	0
219	Teapot (Naval Reserve), *Natrona*	1922	3,000	3,543,282	0	0	0	0	59	0	0
220	Teapot (Outside Reserve), *Natrona*	1927	40	134,382	4,749	0	0	0	3	0	0
221	Thornton, *Crook, Weston*	1915	0	463	0	0	0	0	15	0	0
222	Torchlight, *Big Horn*	1913	600	199,284	0	0	0	0	87	0	0
223	Wagonhound, *Hot Springs*	1944	320	14,048	14,048	0	0	0	1	1	0
224	Wakeman Flats, *Crook*	1919	0	Non-Com.	0	0	0	0	5	0	0
225	Walker Dome,* *Hot Springs*	1930	0	0	0	160	0	0	1	0	0
226	Warm Springs, *Hot Springs*	1917	180	516,821	14,663	0	0	0	39	0	0
227	Waugh, *Hot Springs*	1934	100	192,611	0	0	0	0	2	0	0
228	Wertz, *Carbon, Sweetwater*	1920–35	650	10,594,408	2,006,262	1,840	65,490	14	30	0	0
229	Winkleman, *Fremont*	1944	260	117,781	117,781		0	0	4	4	0
230	Total Wyoming			632,771,864	33,245,333		553,620[e]	36,001[e]	5,891	183	30

[e] Preliminary figures. Gas wasted, recycled or used in field without metering not included.

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.		Character of Oil[i]		Producing Formation					Deepest Zone Tested[p] to End of 1944	
	Oil													
	Flowing	Artificial Lift	Gas	Initial	Avg./End 1944	Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
198	0	37	2			37	0.1	Dakota group, Cre Sundance, Jur	S S	2,500 3,000	35 50	A	Casper	5,671
199	0	0	0			15	4.2	Minnelusa, Pen	S	175+	15	T	Pahasapa	1,323
200	0	0	0			21	3.4	Chugwater, Tri	S	675	20	A	Madison	1,958
201	27	1,331	0			36	−0.1	Niobrara, Carlile, CreU Frontier, Muddy, CreU Lakota, CreL Morrison, Sundance, Jur	Sh S S S	370–2,310 900–2,800 2,280–2,700 2,865–3,130	40 168 40 40	Df	See below	
202	13	0	0			27	2.2	Tensleep, Pen	S	3,775	80	Df	Granite	5,420
203	0	0	0			24	0.2	Steele (Shannon), CreU	S	730+	50	M	Frontier	3,245
204	0	0	0			25	−0.1	White River, Olig	S	450+	10	MU	Granite	2,940
205	0	0	0			23	2.8	Embar, Per	L	2,150	55	A	Tensleep	3,290
206	0	0	0					Frontier, CreU	S	2,600	50	D	Chugwater (Drg)	5,739
207	0	0	1	965–1,050	x			Frontier (Abd), CreU Cloverly, CreL	S S	2,315 2,950	15 25	A	Tensleep	5,185
208	0	2	0			19	3.4	Frontier-Muddy (Abd), CreU Embar-Tensleep, Per, Pen	S L, S	1,100 4,300	x 50	A	Amsden	4,795
209	0	6	0			22	0.1	Mesaverde (Quealy), CreU	S	665	40	D	Frontier?	6,931
210	0	20	0			16	4.4	Sundance (G Abd), Jur Tensleep, Pen	S S	1,350 2,430	x	D	Madison	3,175
211	0	0	0			15	4.0	Tensleep, Pen	S	3,800	50	A	Amsden	4,254
212	0	0	0			18	3.1	Embar, Per	L	2,480	35	D	Tensleep	2,845
213	0	3	0			19	2.7	Madison, MisL	L	505	5	D	Big Horn	1,506
214	0	5	0			20	3.3	Sundance, Jur Tensleep, Pen	S S	1,025 2,200	40 30	D	Amsden	2,807
215	0	8?	0			40	−0.1	Frontier, Aspen, Bear River, Cre	S	500–2,000	20	MU	Bear River (?)	?
216	0	1	0			38	0.1	Frontier (G), CreU Lakota (O), CreL	S S	2,760 4,400	100 11	A	See below	
217	0	6	0			27	2.2	Sundance (Nugget), Jur Tensleep, Pen	S S	5,092 6,772	60 164	A	Tensleep	7,104
218	0	0	0			17	0.1	Bear River, CreU	S	660	15	x	x	2,025
219	0	0	0			36	−0.1	Shannon, Niobrara-Carlile, CreU Frontier	Sh S	947+ 2,883+	var. 84	Df	Frontier	3,340
220	0	3	0			36	−0.1	Shannon, Niobrara, CreU	S	2,400	var.	D	Frontier	3,340
221	0	0	0			40		Carlile, CreU	S	600	30	T	Graneros	1,050
222	0	0	0			40	0.1	Mowry, CreU	S	400+	50	D	Madison	4,165
223	0	1	0			28	1.4	Embar, Per	L	4,300	24	A	Tensleep	4,700
224	0	0	0			39	−0.1	Carlile, CreU	S	500–1,200	15	T	Fall River	2,159
225	0	0	0					Frontier, CreU	S	3,130	10	D	Cloverly	4,412
226	0	12	0				3.4	Embar, Per	L	850	40	D	Amsden	1,945
227	0	0	0			28	1.7	Embar, Per	L	3,780	30	D	Tensleep	4,242
228	13	4	4			36	1.3	Cloverly (G), CreL Tensleep (O), Pen	S S	3,000 5,800	20 170	D	Amsden	6,700
229	0	4	0					Tensleep, Pen	S	2,877	260	D	Tensleep	3,534
230	209	3,119	151											

TABLE 2.—*Summary of Drilling Operations in Rocky Mountain Region*

Important Wildcats Drilled in 1944

	County	Structure	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day		Remarks
			Sec.	Twp.	Rge.					Oil, U.S. Bbl.	Gas, Millions Cu. Ft.	
						COLORADO						
1	Weld	Hardin	20	5 N	63 W	7,985	Recent	Lykins	Ohio Oil Co.			Dry
2	Moffat	Bell Rock	4	6 N	92 W	9,084	Williams Fork	Sundance	Stanolind O. & G. Co.			Dry
3	Larimer	North Fort Collins	18	8 N	68 W	4,759	Pierre	Upper Dakota	Trigood Oil Co.	75		Oil, "Muddy," extension?
4	Larimer	North Wellington	32	11 N	68 W	6,960	Pierre	Lower Dakota	Amerada Petr. Co.			Dry
5	Garfield	Webster Hill	22	6 S	94 W	3,700	Wasatch	Wasatch	Wasatch O. R. Co.			Dry
6	Cheyenne	Kit Carson	24	13 S	49 W	4,861	Pierre	Marmaton	O. E. Torrey			Dry
7	Montezuma	McElmo	24	36 N	18 W	7,046	Navajo	Elbert	Stanolind O. & G. Co.			Dry
						MONTANA						
8	Yellowstone	Broadview	18	3 N	23 E	5,385	Eagle	Madison	Broadview Petr. Co.			Dry
9	Yellowstone	Crooked Creek	15	4 N	26 E	6,590	Lance	Madison	Carter Oil Co.			Dry
10	Yellowstone	Custer	2	6 N	32 E	8,614	Lance	Cambrian	Carter Oil Co.			Dry
11	Rosebud	Ingomar	27	9 N	35 E	5,910	Judith River	Madison	Northern Ordnance			Dry
12	Fergus	Button Butte	20	14 N	24 E	3,312	Ellis	Madison	R. C. Tarrant			Dry, suspended
13	Liberty	East Utopia	14	33 N	4 E	2,610	Colorado	Madison	Texas Company		5	Gas, extension?
14	Hill	Hingham	25	33 N	10 E	4,018	Judith River	Madison	Hingham-Hobson			Dry, suspended
15	Liberty	Prescott Block	19	34 N	6 E	3,200	Eagle	Madison	Texas Company			Dry
16	Toole	Kicking Horse	8	36 N	1 E	2,040	Eagle	Madison	Husky Ref. Co.		20	Gas, new field
17	Liberty	Keith (Bears Den)	29	36 N	6 E	3,221	Eagle	Madison	Texas Company			Gas, Ellis (1945)
18	Liberty	Whitlash	22	37 N	4 E	4,068	Colorado	Cambrian	Union Oil Co.			Deep test, plugged back
19	Liberty	Flat Coulee	10	37 N	5 E	3,132	Judith River	Madison	Northern Petroleum			Oil, P.B. Kootenai
20	Liberty	Lost Creek	22	37 N	7 E	4,193	Judith River	Big Snowy?	Smith et al.			Dry, suspended
21	Teton	Pondera	23	27 N	4 W	5,234	Colorado	Pre-Cambrian	A. B. Cobb et al.			Dry
22	Teton	West Pendroy	21	27 N	6 W	3,537	Virgelle	Madison	R. G. Anderson			Dry
23	Pondera	Conrad-Midway	32	28 N	1 W	3,695	Colorado	Jefferson	R. C. Tarrant			Dry, deep test
24	Pondera	S. Cut Bank	3	31 N	6 W	3,284	Two Medicine	Madison	Hannah-Porter Co.			Dry
25	Glacier	Meriweather	17	33 N	9 W	6,108	Two Medicine	Madison	A. B. Cobb & Co.			Dry
26	Sweetgrass	McLeod	16	2 S	13 E	2,992	Eagle	Amsden	Stanolind O. & G. Co.			Dry
27	Yellowstone	Mifflin	17	2 S	29 E	4,284	Colorado	Madison	Carter Oil Co.			Dry
28	Carbon	Roscoe	4	6 S	18 E	4,165	Livingstone	Madison	R. C. Tarrant			Dry
29	Carbon	Fox-Luther	14	6 S	19 E	7,691	Lance	(Drilling)	Carter Oil Co.			Abd. 8921—Morrison, 1945
30	Carbon	Dry Creek	3	7 S	21 E	8,882	Lance	Cambrian	Ohio Oil Co.	300		Deep test, P.B. Morrison oil
31	Carbon	Clark Fork	25	9 S	22 E	6,531	Lance	Frontier	General Petr. Corp.	124		New oil field

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1944

No.	County	Structure	Location Sec.	Location Twp.	Location Rge.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U.S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Remarks
	SOUTH DAKOTA											
32	Harding	Gustave	32	15 N	2 E	7,038	Fox Hills	Deadwood	Northern Ordnance			Dry
33												
	UTAH											
34	Summit	Coalville	35	3 N	5 E	4,423	Frontier	Frontier?	Longwall Petr. Co.			Dry
35	Grand	Cisco	23	20 S	21 E	4,744	Mancos	Granite	Continental Oil Co.			Dry
	WYOMING											
36	Carbon	Cooper Cove	20	18 N	77 W	5,373	Mesaverde	Jelm	Stanolind O. & G. Co.	153		Oil, Cloverly, new field
37	Albany	East Rock River	33	21 N	76 W	3,454	Steele	Sundance	Wasatch Prod. Co.			Dry
38	Carbon	Bell Springs	6	23 N	88 W	3,852	Steele	Tensleep	Rocky Mt. Gas Co.		4	Gas, Sundance, new field, 2,272
39	Carbon	Bailey Dome	21	26 N	89 W	5,234	Recent	Sundance	Sinclair-Wyo. Oil Co.	634		Oil, Sundance, new field
40	Fremont	Barren Butte	32	27 N	92 W	4,880	Wasatch	Lewis	Continental Oil Co.			Dry
41	Fremont	Spring Creek	7	28 N	92 W	4,808	Steele	Thermopolis	Phillips Petr. Co.			Dry, suspended
42	Fremont	Spring Creek	7	28 N	92 W	3,103	Steele	Cloverly	Phillips Petr. Co.			Dry, suspended
43	Fremont	Crooks Gap	18	28 N	92 W	5,315	Steele	Cloverly	Sinclair-Wyo. Oil Co.	1,478		Oil, Cloverly, new field
44	Natrona	Spindletop	32	30 N	81 W	2,445	Frontier	Tensleep	G. W. Jarvis	250		Oil, Tensleep, deep zone
45	Natrona	Two Bar	24	31 N	81 W	4,047	Carlile	Madison	Pacific Western O. Corp.			Dry
46	Converse	Shawnee	27	32 N	69 W	4,849	White River	Minnelusa	G. P. Dickey			Dry
47	Natrona	Iron Creek	11	32 N	82 W	3,437	Frontier	Tensleep	Texas Company			Dry
48	Fremont	Big Sand Draw	14	32 N	95 W	7,593	Wind River	Tensleep	Sinclair-Wyo. Oil Co.	1,101		Oil, Tensleep, deep zone
49	Niobrara	Little Buck Creek	25	36 N	64 W	4,100	Pierre	Lakota	Continental Oil Co.	546		Oil, "Dakota," new field
50	Natrona	Powder River	23	36 N	85 W	4,889	Niobrara	Madison	Stanolind O. & G. Co.		6	Gas, Sundance, new zone
51	Fremont	Poison Creek	16	37 N	93 W	4,182	Wind River	Lewis	Stanolind O. & G. Co.			Dry
52	Hot Springs	Kirby Creek	21	43 N	92 W	4,427	Cody	Madison	Pacific Western O. Corp.	20		Oil, Embar, deep zone
53	Weston	Mush Creek	24	44 N	63 W	3,867	Pierre	"Muddy"	Western Oil Trust			Oil, new field
54	Hot Springs	Wagonhound	6	44 N	98 W	4,700	Cody	Tensleep	Broderick & Gordon			Oil, Embar, new field
55	Hot Springs	Golden Eagle	12	45 N	97 W	6,794	Fort Union	Thermopolis	Pioneer Oil Corp.	16	?	Oil, "Muddy," new zone
56	Hot Springs	Little Grass Creek	11	46 N	99 W	6,632	Cody	Madison	Continental Oil Co.		4	Gas, "Muddy," new zone
57	Park	Little Buffalo Basin	34	48 N	100 W	5,944	Cody	Madison	Stanolind O. & G. Co.			Dry (west dome)
58	Park	Half Moon	23	51 N	102 W	4,265	Frontier	Madison	Husky Ref. Co.	200		Oil, Embar, new field
59	Big Horn	Alkali	33	55 N	95 W	3,525	Thermopolis	Madison	Yale Oil Co.			Dry
60	Park	S. Elk Basin	20	57 N	99 W	Drlg.	Fort Union		Continental Oil Co.			Gas, 1944; oil, 1945
61	Fremont	Winkleman	18	2 N	1 W	3,315	Thermopolis	Tensleep	Stanolind O. & G. Co.	860		Oil, Tensleep, new field
62	Fremont	Little Dome	10	5 N	1 W	4,111	Thermopolis	Tensleep	Superior Oil Corp.			Dry
63	Fremont	Little Dome	10	5 N	1 W	4,150	Thermopolis	Chugwater	Superior Oil Corp.			Dry
64	Fremont	Dry Creek	27	6 N	3 W	4,191	Frontier	Chugwater	Sinclair-Wyo. O. Co.			Dry
65	Fremont	Steamboat Butte	31	4 N	1 W	7,034	Cody	Tensleep	Brit. Amer. O. Prod. Co.	577		Oil, Tensleep, deep zone

newer blocks were just beginning to be negotiated.

Changes in crude-oil prices permitted by the Office of Price Administration were nominal. Moffat, Rangely (Weber), and Wilson Creek, in Colorado, received increases of 5¢ per barrel. Kevin-Sunburst in Montana received a 20¢ increase for oil of 37° and above A.P.I. gravity. Big Medicine Bow, Big Muddy, Gebo (Embar), Grass Creek, Iron Creek, Lance Creek, Lost Soldier (Tensleep), Pilot Butte, and Salt Creek (light) in Wyoming were increased 2 to 11¢ per barrel. These increases in some cases restored the Mid-Continent price schedule to light-oil fields; in others, they adjusted differentials between pools or types of oil.

Office of Price Administration Revised Maximum Price Regulation No. 436 permitted subsidy payments of 20 to 35¢ per barrel in about four fields in Colorado, eight in Montana, and 25 in Wyoming. The 35¢ payment applies to 26 of the pools.

A list of 217 past or present fields in which oil or gas wells have been, or apparently could have been, completed is given in Table 1, with pertinent facts regarding them. This list is intended to include all areas in which oil or gas in possible productive amounts has been found.

An abbreviated list of 61 wildcat wells is given in Table 2. The figures indicate that 171 wildcat wells were drilled or drilling in Colorado, Montana, Utah, and Wyoming in 1944, but many of them were shallow or incomplete. The list has been confined mainly to completed wells and those more than 3000 ft. deep, although many wells, particularly in Montana, reach their objective at shallower depths. Some of the discoveries listed herein were in zones in known fields above the deepest formation tested and are not listed among the wildcat wells. A brief summary of developments is given in the following paragraphs.

Colorado

Thirty-one oil wells were completed in Colorado, as compared with 16 in 1943. No gas wells were drilled, and gas production declined about 600,000,000 cu. ft. A new high in oil production was attained, due to new wells in the Clark Lake, North McCallum, Rangely, and particularly the Wilson Creek field. Other fields had nominal changes. Although only three completions were made in the Rangely Weber pool, and three rigs were in operation at the end of the year, this pool will be extensively drilled in 1945. The Weber had been practically shut in with one oil well since 1933.

An average of five oil reserve estimates, three of which were published, indicates that the 1944 development increased the reserves 40,000,000 bbl., or nearly 100 per cent. Twenty-two wildcat wells were drilling, the same number as in 1943, but they had little effect on the reserves.

The only discovery was by the Amerada Petroleum Co., in the Clark Lake field, which was reported last year. The well was drilled to 6510 ft. in the Sundance formation in 1943, and completed in the Upper Dakota or Muddy sand in February 1944. The well is 1391 ft. lower structurally than the lowest well producing in the old Wellington field, 2½ miles west, and is a reflection-seismograph discovery.

Exhaustive tests of the Frontier Refining Company's well at White River, which was drilled to 7005 ft. in 1943, indicated only small production of gas and condensate, and operations were suspended. Testing of the Continental Oil Company's 1943 well at South McCallum also indicated small production and it was shut in. The Fort Collins field was extended ¾ mile north or a separate pool was found by the Fred Goodstein Community well. An extension was also reported at Powder Wash, but the new well is only ½ mile northeast or southeast from two older wells. The west side

of this field was proved disappointing and erratic by a dry hole nearly between two producing wells and less than ¼ mile from one of them.

A pilot plant was erected in the North McCallum field to separate carbon dioxide gas from oil, and tests showed the practicability of returning the gas to the reservoir. A combined extraction and repressuring plant was erected to operate in 1945.

A 6-in., 108-mile pipe line was completed by the Utah Oil Refining Co. in October, from the Iles field via Craig to Wamsutter, Wyoming, where it connects with the Lance Creek-Salt Lake City line. Later a permit was granted to extend this line to Rangely. The Clark Lake field was connected with the branch line at Wellington and the Rocky Mountain Pipe Line Co. line to Denver by a line ¾ mile line long. This eliminates trucking of the oil to Denver.

Montana

About 219 oil wells and 81 gas wells were completed, as compared with 158 and 51, respectively, in 1943. Oil production at Kevin-Sunburst, Cut Bank, and Pondera increased somewhat, production at Gage and Thorpe commenced, and the Montana part of the Elk Basin field produced 423,000 bbl. more than in 1943. Gas production increased about one billion cubic feet.

Oil reserves changed very little, some estimates used showing a small increase, others a small decrease. The wildcats drilling included 73 wells, the same number as in 1943. The Texas Company succeeded Northern Ordnance, Inc., as the leading wildcatter.

New discoveries included gas at Kicking Horse and oil at Clark Fork. A large gas well was completed at East Utopia, about 1¼ miles east of a small oil well of 1943. Results of drilling at Brady, Conrad-Midway, Farmington and other localities were disappointing.

New producing zones included a Sunburst sand well in the Thorpe pool, north of Kevin-Sunburst, with an initial production reported of 280 bbl. of 39° A.P.I. gravity oil; and a Morrison well at Dry Creek, which reported an initial production of 300 bbl. of 53° A.P.I. gravity oil in a well drilled to the Cambrian at 8882 ft., with no oil below the Morrison at 5905 feet.

The Texas Company completed an outpost oil well 2 miles northeast of the Kevin-Sunburst field in the SW¼ NE¼ sec. 20, T. 36 N., R. 1 W. in the so-called Willshaw area, but a well in the NW¼ NW¼ sec. 19 was dry. Prevol and Shay completed two wells in the SW¼ SW¼ sec. 10, T. 35 N., R. 3 W. and Pacific Western Oil Corporation followed with wells in the SE¼ SE¼ sec. 4 and the SW¼ NW¼ sec. 9, opening about 2 miles of new territory northwest of previous production.

A. B. Cobb and Co. received a permit to lay 90 miles of 5-in. line from the Cut Bank field via Pondera to the Home Oil Co. refinery at Great Falls. About 12 miles of the line north of Conrad had been laid at the end of the year. Other lines are discussed under Wyoming.

Utah

Five wildcat wells were drilling in Utah, as compared with nine in 1943. A well at Coalville, started in 1932, was finally abandoned at 4423 ft., probably drilling the Frontier formation all the way. The Continental-Union Oil Co. well at Cisco dome was abandoned at 4744 ft. in granite underlying the Moenkopi formation. The other wells were shallow or incomplete. Four shallow wells also were reported drilled in the old San Juan or Mexican Hat area, with some oil showings. Since the depletion of the Ashley Valley gas field in 1941, and the suspension of production in the small Virgin oil field in 1942, the only production in Utah has been from the Clay Basin gas field and the Farnham

carbon dioxide field. No drilling has been done at Clay Basin since 1941. Several large companies, however, have geologists in the state and expect to drill or drill deeper some of the untested or partly tested structures.

Wyoming

Completions in Wyoming included 177 oil wells and 6 gas wells, as compared with 102 and 5, respectively, in 1943. Oil production increased 100,000 bbl., or more at Big Muddy, Cole Creek, Elk Basin (black), Frannie, Garland, Salt Creek (black), and Steamboat Butte (black). Gebo and Winkleman contributed the most among the new fields. Several fields discovered late in the year produced little or no oil in 1944, but should increase the production in 1945. The largest declines were at Byron, Grass Creek (black), Lance Creek, Lost Soldier, South Oregon Basin, and Salt Creek (light).

An average of reserve estimates as used for Colorado and Montana gives Wyoming an increase of 50,000,000 bbl., which seems conservative. Three of the estimates were considerably higher, while two showed little change. Only in Wyoming did wildcat drilling increase, from 59 wells in 1943 to 71 in 1944.

Discoveries of new fields, pools or possible productive zones were numerous, and some information regarding them is given in Table 3.

Table 3.—*Discoveries in Wyoming*

Field	Formation	Depth, Ft.	Type
Bailey dome	Sundance	5,160	New oil field
Bell Springs	Sundance	2,270	New gas field[a]
Big Sand Draw	Embar	6,935	Gas and condensate
Big Sand Draw	Tensleep	7,285	Deep oil zone
Cooper Cove	Cloverly (Dakota)	4,834	New oil field
Crooks Gap	Cloverly (Lakota)	5,230	New oil field[a]
Elk Basin	Embar	5,620	New oil zone
Garland	Tensleep	4,300	Oil ring
Golden Eagle	Muddy	6,720	Gas and condensate (New zone, depleted gas field)
Half Moon	Embar	3,426	New oil field
Kirby Creek	Embar	3,420	Deep oil zone
Lance Creek	Morrison	3,400	New oil zone
Little Buck Creek	Dakota	3,850	New oil field
Little Buffalo Basin	Dakota	2,305	[b]
Little Buffalo Basin	Muddy	2,198	[b]
Little Buffalo Basin	Embar	4,300	New oil zone
Little Grass Creek	Muddy	3,580	Deeper gas zone
Powder River	Sundance	2,490	Deeper gas zone
South Oregon Basin	Lower Madison	4,620	Deep oil zone
Spence Dome	Amsden-Madison	410–550	New oil field[a]
Spindletop	Tensleep	2,226	Deep oil zone
South Elk Basin	Frontier	4,354	[b]
South Elk Basin	Cloverly	5,390	[b]
Steamboat Butte	Cloverly (Lakota)	4,500	New oil zone
Steamboat Butte	Tensleep	6,770	Deep oil zone
Wagonhound	Embar	4,260	New oil field
Winkleman	Tensleep	2,915	New oil field[a]

[a] Oil or gas reported prior to 1930 abandoned with no reported production.
[b] Drill-stem tests of gas sands in wells drilling to Tensleep oil.

Because of the numerous producing formations in some areas, and possible production not consummated in the early days of drilling, it is difficult to adopt a standard classification of discoveries in this region. On the basis of present information, Big Sand Draw, Garland, Steamboat Butte, and Winkleman are the most important of these discoveries.

Previous to 1944, the Garland field had only one small Tensleep well at the northwest end of the field, which was completed in 1929 by the Kinney Coastal Oil Co., deepened, plugged back, and otherwise worked over, and produced part of the

time. The smaller area of the field with Madison oil wells has a Tensleep gas cap, and the existence of an oil ring was not known until the General Petroleum Corporation drilled its Howell No. 1 well in lot 63-B, T. 56 N., R. 97 W. on the southwest flank of the structure 3½ miles southeast of the original well. In the South Oregon Basin field, a discovery was made in the upper Madison in 1942, and a lower zone was discovered in 1944. The Madison wells have not been produced, and the importance of this pool is not known, but it probably exceeds that of many of those listed above.

The main high light in pipe-line construction was the completion of the 232-mile, 12-in. line from Elk Basin to Casper in October. This line serves Elk Basin, Oregon Basin, Little Buffalo Basin, Grass Creek, Gebo, and other fields on the west side of the Big Horn Basin. It leaves the Big Horn Basin southeast of Kirby and enters the Wind River Basin north of Lysite. An extension may be projected westward to the Pilot Butte and Steamboat Butte fields.

An 8-in., 23-mile line from Bairoil to Crooks Gap was practically completed. This line will be extended to Big Sand Draw in the spring of 1945. A 6-in. and 8-in., 80-mile line from Elk Basin to Laurel and Billings, Montana, was completed and put in operation by The Leader Oil Co., a subsidiary of the Carter Oil Co., in October. Branch lines from Byron and Frannie connect with this line at Warren, Montana.

The old gas line from Big Polecat, Wyo., to Warren, Mont., was replaced by a new 2-in. and 3-in. line. An 8½-mile, 5½-in. gas line was completed from the Bell Springs field to the Bunker Hill-Mahoney-Rawlins line. A 2½-mile, 4-in. line was laid from the Beaver Creek field to the Big Sand Draw-Riverton line.

Oil and Gas Developments in Tennessee in 1944

By Kendall E. Born*

Production of crude oil in Tennessee during 1944 was slightly more than 9500 bbl., about 1300 bbl. more than 1943. Approximately 8000 bbl. was produced from the "Mississippi lime" in Scott and Morgan Counties. Some half dozen wells in Clay, Pickett, and Fentress Counties, pumped intermittently, produced about 1500 bbl. This production is from rocks of Ordovician age ranging in depth from less than 500 ft. to approximately 1000 ft. Natural gas was marketed from wells in Morgan and Fentress Counties for consumption in the Sunbright and Jamestown areas, respectively.

The production of oil by counties is shown in Table 1.

Table 1.—*Oil Production in Tennessee in* 1944

County	Number of Wells Wells Pumped	Production, Bbl.	
		1943	1944
Scott and Morgan.......	10	7,2xx	8,xxx
Clay, Pickett, Fentress...	5	1,xxx	1,5xx

Developments

There were 20 completions during 1944 totaling 19,615 ft., nearly twice as much as in 1943. One well was drilling on Dec. 31, 1944. Of the 20 completions, one was a small oil well soon abandoned. Three gas wells were completed which are used locally. The completions are listed in Table 2. The distribution of tests according to physiographic divisions is given in Table 3.

Cumberland Plateau

There were five completions in the northern part of Cumberland Plateau. One was a small gas well in the Cooper pool 3 miles west of Oneida, but an attempt to extend the pool to the south resulted in a dry hole.

The most active area in the state during 1944 was the northern Cumberland Plateau, especially in Cumberland, Morgan, and Scott Counties. Several blocks, aggregating more than 500,000 acres, were assembled and leasing was continuing in the early part of 1945.

Surface work has been, or is being, carried on by at least four companies. While in an area of past oil and gas production from the "Mississippi lime," the principal interest appears to be in the essentially unexplored pre-Mississippian possibilities. The Knox dolomite group of Cambro-Ordovician age is receiving some attention as a possible reservoir. As the year closed one well was drilling on a surface structure near Lantana, 6 miles southwest of Crossville. This test will be drilled into the upper part of the Knox.

Late in 1944, it was planned to lay a gas line from northern Morgan County to Oneida in Scott County, a distance of approximately 20 miles.

Middle Tennessee

Fifteen wells were drilled in Middle Tennessee. In the northeastern Highland Rim area there were 11 completions, one

Published with permission of the State Geologist of Tennessee. Manuscript received at the office of the Institute June 11, 1945.

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TABLE 2.—*Oil and Gas Tests Drilled in Tennessee during 1944*

Line Number	County	Location	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Remarks
1	Scott	3 miles W.-SW. of Oneida	1,860	Pen	Richmond (Ord)	Clock Oil Co.	Extends Cooper gas pool
2	Scott	3½ miles SW. of Oneida	1,656	Pen	Lower Mis	Clock Oil Co.	Limits Cooper pool to the south
3	Scott	4 miles NW. of Oneida	890	Pen	Upper Mis	C. S. Beck et al.	Dry hole in old Grave Hill Pool
4	Scott	4 miles NW. of Oneida	1,150	Pen	Middle Mis	C. S. Beck et al.	Dry hole in old Grave Hill pool
5	Fentress	4 miles NE. of Grimsley	1,990	Pen	Trenton (Ord)	Travis Smith	Dry Trenton test
6	Fentress	½ mile W.-SW. of Little Crab	850	Lower Mis	Trenton (Ord)	Andre and Petersen	Attempt to extend old Riverton production
7	Fentress	1 mile W.-SW. of Little Crab	518	Lower Mis	Trenton (Ord)	Andre and Petersen	Attempt to extend old Riverton production
8	Fentress	3½ miles E.-SE. of Pall Mall	1,275	Lower Mis	Trenton (Ord)	York and Koger	
9	Fentress	4 miles W.-SW. of Pall Mall	1,070	Lower Mis	Black River (Ord)	Dobbs Oil Co.	
10	Pickett	1 mile E. of Static	1,135	Middle Mis	Stones River (Ord)	Koger and York	Gas well used locally
11	Pickett	3 miles NW. of Pall Mall	861	Middle Mis	Trenton (Ord)	York and Koger	Good shows in "Beaver sand" above Chattanooga shale
12	Putnam	2 miles S.-SE. of Cookeville	850	Middle Mis	Black River (Ord)	Salem Oil and Gas Co.	Gas well on surface structure
13	Putnam	2 miles S.-SE. of Cookeville	563	Middle Mis	Trenton (Ord)	Salem Oil and Gas Co.	Unsuccessful attempt to extend production
14	Putnam	2 miles S.-SE. of Cookeville	635	Middle Mis	Trenton (Ord)	Salem Oil and Gas Co.	Unsuccessful attempt to extend production
15	Putnam	2 miles S.-SE. of Cookeville	600	Middle Mis	Trenton (Ord)	Salem Oil and Gas Co.	Unsuccessful attempt to extend production
16	Clay	6 miles N.-NW. of Celina	522	Trenton (Ord)	Stones River (Ord)	J. H. Overstreet	Small oil well; soon abandoned
17	Lincoln	3½ miles W.-NW. of Blanche	718	Trenton (Ord)	Stones River (Ord)	S. S. Hall et al.	
18	Dickson	4 miles E. of Charlotte	369	Lower Mis	Sil	Dickson County Oil and Gas Trust	Considerable amount of free oil at 360 to 365 ft.
19	Dickson	4 miles E. of Charlotte	1,003	Lower Mis	Stones River (Ord)	Dickson County Oil and Gas Trust	In area of past production
20	Dickson	4 miles E. of Charlotte	1,100	Lower Mis	Stones River (Ord)	Dickson County Oil and Gas Trust	In area of past production

TABLE 3.—*Physiographic Distribution of Wells Drilled in Tennessee in 1943*

Physiographic Divisions	County	Wildcat	In Proven Field	Oil Wells	Gas Wells
Northern Cumberland Plateau	Scott	2	2	0	1
	Fentress	1	0	0	0
Eastern Highland Rim	Fentress	4	0	0	0
	Pickett	2	0	0	1
	Putnam	1	3	0	1
	Clay	0	1	1	0
Central Basin	Lincoln	1	0	0	0
Western Highland Rim	Dickson	3	0	0	0

of which was a small producer in the Pine Branch pool in Clay County, but it was soon abandoned because of salt water. Two unsuccessful wells were drilled in eastern Fentress County in an attempt to extend the old Riverton production to the north.

Near Cookeville, Putnam County, a test found gas in fractured zones in the Trenton (Ordovician) in what is believed to be commercial quantities. The discovery well was soon offset to the northeast, northwest, and west, by dry holes.

In central Dickson County a well found free oil in the lower part of the Silurian at 360 to 365 ft., but water was encountered immediately below and the well has been temporarily abandoned. Two near-by tests were dry. There has been sporadic production in this part of Dickson County since 1866.

There was little leasing activity in Middle Tennessee during the year. Small blocks were assembled in the upper Cumberland district in Pickett and Fentress Counties and a sizable block was taken by one of the major companies in Macon County on the northern Highland Rim.

West Tennessee

There were no completions in the Mississippi embayment area of West Tennessee. Some acreage was taken in southern Haywood County and southeastern McNairy County and some surface work was done in both areas.

A Summary of Shutdown Orders and Proration in Texas for the Year 1944

By R. B. Gilmore,* Junior Member A.I.M.E.

It has been the custom of the Railroad Commission of Texas to hold hearings each month with respect to existence and imminence of waste of oil and gas in Texas and its prevention, and to issue orders restricting the production of oil to the reasonable market demands and allocating production to the various fields in Texas. The practice of designating the actual days during the month on which wells are to be shut down was discontinued in the order for November 1942, and orders issued thereafter contain only the number of shut-in and producing days for the month.

Orders issued by the Railroad Commission are divided into two main subdivisions, the first a general shutdown order of all oil wells in the various fields in Texas, and second, the exception of certain fields to this general order. Table 1 shows the producing days for all of the fields in Texas for 1944 under the first of these classifications:

Table 1.—*Producing Days, All Fields in Texas*, 1944

Month	Allowed Number of Producing Days	Month	Allowed Number of Producing Days
Jan.	23	July	24
Feb.	21	Aug.	24
Mar.	23	Sept.	24
Apr.	23	Oct.	24
May	24	Nov.	24
June	23	Dec.	24
Total			281

Manuscript received at the office of the Institute June 11, 1945.

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The fields that have producing schedules varying from the general order may be divided roughly into three subdivisions, as follows:

Table 2 shows the producing days for certain fields that were prorated as a group throughout 1944. Other fields which were occasionally included with this group were also prorated under the general order and by special orders. The producing days for these irregular fields are shown in Table 4.

Table 2.—*Producing Days, Fields Prorated as Group*, 1944

Month	Allowed Number of Producing Days	Month	Allowed Number of Producing Days
Jan.	28	July	28
Feb.	26	Aug.	28
Mar.	28	Sept.	28
Apr.	27	Oct.	28
May	28	Nov.	28
June	27	Dec.	28
Total			332

Districts	Fields
No. 2	Harmon, West Mauritz, Mayo
No. 3	Amelia
No. 4	Orange Grove
No. 9	Antelope (Miss.), Bindel, Bonita, Chapman-McFarlin, Clingingsmith, Cooper, Forestburg, Hapgood, Hoefle, Kadane, Kadane-Shallow, Knox (Miss.), Mankins, Mueller, Padgitt (Miss.), Ringgold, Rock-Crossing (Ellenb.), Sanders, Scotland, Scotland (Miss.), Wilson, Worsham-Steed.

In Table 3 are listed fields that were exempted from any shutdown days during December 1944, the majority retaining this exception throughout 1944. Certain fields included in the general order were added to this group on the first day of the month shown.

TABLE 3.—*Fields Exempted from Shutdown Days*, 1944

DISTRICT NO. 1

Charlott	Oct.	Loma Alto		Pearsall (Navarro)	
Darst Creek		Loma Alto (Wilcox)	Aug.	Salt Flat	
Green Branch		Luling-Branyon		United	July
Lentz	Dec.				

DISTRICT NO. 2

Blanconia		Koontz	Nov.	Pettus	
Burnell	Aug.	La Salle	Mar.	Plummer	
Caesar, South		La Rosa, North		Pridham Lake	Sept.
Cordele		Little Kentucky		Ray	June
Cosden, West	Mar.	Mauritz		Terrell Point	Mar.
Fagan		Mauritz, East	Nov.	Victoria	
Ganado, West		Melon Creek		Warmley	May
Goebel		Mission River		Weesatche	July
Green	Aug.	Oakville		White Creek	
Heyser					

DISTRICT NO. 3

Alief		El Campo	April	North Winnie	June
Arriola		Esperson Dome		North Withers	
Bammel		Eureka Heights		Orange, West	
Barbers Hill		Fannett		Oyster Bayo	
Batson New		Goose Creek		Port Neches	
Bay City, North		Hastings		Port Neches, West	
Beaumont, West		High Island		Raccoon Bend	
Beech Creek	July	Hithcock		Raccoon Bend (Cockfield)	
Beech Creek, North	July	Hull		Ramers Island	Mar.
Boling		Humble		Red Fish Reef	
Buckeye		Humble Light		Sandy Point	
Cedar Point		Jackson Pasture	Dec.	Silsbee	
Cistern		Kirby		Silsbee, West	
Clay Creek		Kubela		Smith Point	
Clear Lake	Mar.	League City	Sept.	South Houston	
Columbus	July	Livingston		Spring	
Conroe		Lockridge		Stowell	
Conroe, West		Louise		Sugarland	April
Cotton Lake		Magnet-Withers		Thompson	
Cotton Lake, South		Manvel (Oligocene)		Thompson, South	
Cottonwood		Markham		Turtle Bay	
Daboval	Nov.	Mercy		Webster	April
Damon Mound		Mykawa		West Columbia	
Danbury Dome		Mykawa New		West Columbia, New	
Danbury Dome (5655')		North Katy			

DISTRICT NO. 4

Agua Dulce		Eagle Hill		Sam Fordyce, North	
Harper sand		El Tanque		Seeligson	
Gardner or Wardner sand	Sept.	Garcia		Zone 10	April
Lower Austin sand	Oct.	Gregory	Oct.	Zone 13	
Rivers sand		Guerra		Zone 14	
Simmons sand	May	Kreis		Zone 17	
Spoonberg sand		Labbe		Zone 20-E	
Alta Mesa		Las Mujeres	July	Sejita	
Benavides, East		Lockhart		Seven Sisters	April
Boyle		Magnolia City, North		Scott and Hopper	
Brayton		Minnie Bock		Southland	
Brownlee	Sept.	Moca		Sun, North	
Bruni, South	Nov.	Nichols		Taft	[a]
Canales	Sept.	Odem, North	Mar.	Tarancahaus	
Casa Blanca		Plymouth		Thomas Lockhart	April
Charamousca		Rincon, North		Welder	Aug.
Clara Driscoll (3800')		Robinson		White Point	
Dan Sullivan		Rosita	May	White Point, East	
Dougherty	July	Sam Fordyce			

DISTRICT NO. 5

Bazette		Fruitvale	April	Sadler	
Calvert	Dec.	Mexia		Sulphur Bluff	
Campbell	[a]	Powell		Wieland	
Flag Lake		Richland		Wortham	

DISTRICT NO. 6

Boggy Creek		Kildare		Rodessa	
Carthage	Nov.	Lone Star		Sand Flat	May
Cayuga		New Hope		South Tyler	Sept.
Eylau	Oct.	Pittsburg		Talco	
Hawkins	Nov.	Quitman		Winnsboro	May
Henderson (Rusk County)					

[a] Field added on first day of month.

TABLE 3.—(*Continued*)

		DISTRICT NO. 7-B			
Batchler	Mar.	Ewalt	Nov.	Merkel	
Brownville		Hardy	Apr.	Reddin	
Eastland County		Loving		Stephens County	
Erath County		McCaulley			
		DISTRICT NO. 7-C			
Beddo		Clara Couch		World	
Big Lake		Shannon			
		DISTRICT NO. 8			
Apco (1600')		Kermit		P. H. D.	Nov.
Clabberhill		Keystone (Colby)	July	Sand Hills (McKnight)	Aug.
Crane-Cowden		Keystone (Ellenberger)		Smyer	Mar.
Crossett		Keystone (Holt)		Snyder	
Dean	May	Leck		Taylor Link	
Embar (Ellenberger)		Lion		Toborg	
Emma	July	Mabee		Union	
Fort Stockton	Nov.	Mason		Ward, South	Dec.
Hendrick		Masterson		Welch	
Howard-Glasscock		Monahans		Westbrook	
Iatan-East Howard		Monahans, North	May	Wheeler (Ellenberger)	
Iatan, North		Monroe		White and Baker (Lime)	
Jamison-Pollard		Morita	April	Yellowhouse	June
		DISTRICT NO. 9			
Airport		Fargo		Murray (Caddo)	
Allar (Caddo)		Fish Creek		Odell	Dec.
Antelope		Garvey	Mar.	Ord	May
Bindel (Ellenberger)		Garrett	Aug.	Peek	
Burns-Ickert		Henry	Mar.	Rogers-McCrary	
Burns-Midway		Holliday	June	Ross, West	Dec.
Burns-Ragland (Strawn)	July	Hults and Owens		Scaling	July
Burns-Ragland (Miss.)	July	Hundley	Dec.	Stephens	
Chillicothe		Johnson		Votsberger	
Davidson		Joy (Miss.)		Walnut Bend	
Dodson		Knight		Walnut Bend (Montgomery)	June
Edmonds	Mar.	Meyers		Walnut Bend (Winger)	Mar.
Ellis (Strawn)	May	Murray		Walsh	Mar.
		DISTRICT NO. 10			
Bateman Ranch		Panhandle	Aug.		

The Clear Lake, Sugarland and Webster fields in district No. 3, the Hawkins and Talco fields in district No. 6, the Emma field in district No. 8, and the Panhandle field in district No. 10, were changed from special orders to exempt and are listed in Table 4.

Special orders were issued by the Railroad Commission for the remaining fields in Texas. Table 4 summarizes the producing days allowed each field during 1944.

Marginal wells are exempt from shutdown orders. In Texas, a marginal well is defined as any oil well incapable of producing its maximum capacity of oil except by pumping, gas lift, or other means of artificial lift, which, by artificially curtailing its maximum daily production, would be damaged, or result in loss of production ultimately recoverable, or cause premature abandonment of the well. The maximum daily capacity for wells producing from a depth of 2000 ft. or less is 10 bbl., for wells producing from depths between 2000 and 4000 ft. is 20 bbl., between 4000 and 6000 ft. is 25 bbl., between 6000 and 8000 ft. is 30 bbl., and for wells producing from horizons deeper than 8000 ft. is 35 barrels.

Special allowables are granted to discovery wells in Texas based on depth of the producing zone, from a minimum of 20 bbl. daily per well for depths to 1000 ft., and 20-bbl. increments for each additional 1000 ft. of depth. These discovery allowables cover wells in new fields, new producing horizons in old fields, or extensions to producing limits of any known producing horizons for a period of 18 months from

date of satisfactory market outlet, these wells being exempt from all shutdown orders during this period. Provision for these allowables also applies to the first five wells in the new area if all these wells are within ½ mile of the discovery well itself and more than ½ mile from any other group or cluster of wells.

TABLE 4.—*Producing Days during 1944 for Fields Prorated by Special Orders*
NUMBER OF PRODUCING DAYS

District	January	February	March	April	May	June	July	August	September	October	November	December	Total
No. 2													
Tom O'Connor	19	17	19	18	23	23	25	25	28	26	28	29	280
West Ranch	23	21	23	18	19	18	20	20	20	20	20	20	242
No. 3													
Anahuac	23	21	23	23	24	23	24	24	24	24	24	24	281
Clear Lake	28	26	31	30	31	30	31	31	30	31	30	31	360
Sugarland	28	26	28	30	31	30	31	31	30	31	30	31	357
Webster	28	26	28	30	31	30	31	31	30	31	30	31	357
No. 4													
Kelsey	23	21	23	20	21	20	21	21	21	21	24	24	260
No. 5													
Van	23	21	23	23	24	23	25	25	25	25	25	25	287
No. 6													
Coke	26	24	26	23	24	26	27	27	27	19	24	18	291
East Texas	23	23	23	22	23	22	23	24	23	24	23	24	277
Hawkins	17	15	17	23	26	26	30	30	29	30	30	31	304
Talco	31	29	25	26	28	28	31	31	30	31	30	31	351
No. 8													
Abell	23	21	23	23	19	18	19	19	24	24	24	24	261
Cedar Lake	23	21	23	11	20	20	24	24	24	24	24	24	262
Cowden, North	23	21	23	12	21	22	24	27	26	27	26	27	279
Cowden, South	23	21	23	12	23	24	27	27	26	27	26	27	286
Emma	23	21	23	14	21	22	31	31	30	31	30	31	308
Emperor	25	23	25	24	25	26	27	27	26	27	26	27	308
Foster	23	21	23	20	29	29	24	24	24	24	24	24	289
Fuhrman	23	21	23	16	20	20	24	24	24	24	24	24	267
Goldsmith	25	23	25	24	25	25	26	27	26	27	26	27	306
Jordan	23	21	23	23	24	24	28	24	27	27	26	27	297
Mascho	23	21	23	12	20	20	25	25	24	24	24	24	265
Ownby	25	23	25	24	25	25	26	26	25	26	25	25	300
Sand Hills (Ord.)	23	21	17	16	17	16	16	16	15	16	15	16	204
Seminole	23	21	23	23	24	29	30	30	29	29	26	27	314
Slaughter	19	17	19	24	27	27	28	29	29	29	24	24	296
Walker	23	21	23	16	21	22	23	23	22	23	22	23	262
Ward, North	25	23	25	24	25	26	27	27	26	27	26	27	308
Wasson	19	17	19	25	30	23	24	24	24	24	26	27	282
Yates	31	29	31	25	26	26	28	24	24	24	29	27	324
No. 9													
Seymour	25	23	25	25	25	25	26	26	25	26	25	25	301
No. 10													
Panhandle	28	21	23	26	27	27	27	31	30	31	30	31	332

Development and Production in East and East Central Texas in 1944

By D. V. Carter,* Dan C. Williams, Jr.* and John R. Coombs*

Exploration was active in East and East Central Texas during 1944. Ten oil fields were discovered during the year, of which four show promise of development. The discovery wells of the Sand Flat and Tyler, South fields were drilled to a depth greater than 10,000 ft., and the latter field now produces from the Pettit at a depth of 9890 ft. The Sand Flat well was plugged back to the Paluxy. The other two fields are Glen Rose producers near 8000 ft. The Pickton field produces from the Bacon Lime and Winnsboro from the Rodessa section.

The Eylau field, Bowie County, was significant as the first Smackover production in Texas. Magnolia drilled a test in the Concord field, which topped salt.

The most extensive and significant development in the district was the Carthage gas-condensate field. It expanded from the 8000 acres of last year to an estimated 190,000 acres, or about 300 sq. miles, and is not defined as yet. The first oil production in the Carthage area was made from the Travis Peak in 1944 in the Rogers Lacy's Cameron Lumber Company well No. 1, on the northwestern side of the field.

The New Hope field, Franklin County, scored the largest number of completions during 1944 with 24, bringing its total number of wells to 27. Two more pays were opened and produced as dual completions with the older horizons. The Manziel field, Wood County, had 19 new wells added during the year, for a total of 29, while the Pittsburgh field, Camp County, reached a total of 23 wells by completing 14 new ones. Material shortages and drilling restrictions dropped the total number of producing wells completed in the district from 171 during 1943 to 141 for 1944. Abandonments increased from 531 during 1943 to 609 for 1944. Of this number, 479 were in the East Texas field.

Subsidy payments had very little effect in the district and it was mostly a few of the old fault-line fields that had any wells to fall within the requirements for subsidy payments. The prices of crude oil remained constant in the district except for increases as a result of subsidy payments.

Production and Proration

Wartime demands called for increased allowables for many fields, consequently the condensate and oil production for 1944 increased to 190,016,180, which is up 6.9 per cent over 1943.

The East Texas field, of course, remained the principal producer of the district, accounting for 134,768,499 bbl. during the year, or 71 per cent of the district total production of condensate and oil. The field topped its own 1943 production by 4.8 per cent and became the first field in the world to produce 2 billion barrels of oil.

The Hawkins field remained the second largest oil producer in the district, with 13,317,088 bbl. for the year, a drop of 6.8 per cent from 1943, while Van field was third with 11,635,708 bbl. The

Manuscript received at the office of the Institute May 14, 1945.

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TABLE 1.—*Oil and Gas Production in East and East Central Texas*

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[a] To End of 1944	Oil Production: Total Production, Bbl.[a] During 1944
1	Appleby,[1] *Nacogdoches*	1943	0	x	x
2	Barron,[1] *Limestone*	1939	0	6,359	1,643
3	Bazette, *Navarro*	1939	100	261,154	25,218
4	Beulah (Lee-Tex), *Angelina*	1935	10	750	0
5	Boggy Creek, *Anderson, Cherokee*	1925	960	5,220,898	48,255
6	Bolivar, *Denton*	1937	600	14,991	80
7	Bosque, South, *McLennan*	1902	2,500	118,825	2,428
8	Buffalo,[2] *Leon*	1934	10	22,490 17,387	2,124 0
9	Calvert, *Robertson*	1944	30	2,154	2,154
10	Camp Hill, *Anderson*	1935	200	289,030	0
11	Campbell, *Hunt*	1943	80	81,831	56,361
12	Carthage,[2,5] *Panola*	1936 1944	40	753,373 4,025	313,079 4,025
13	Cayuga,[2] *Anderson, Henderson, Freestone*	1934	5,500	2,492,811 32,011,691	398,753 2,894,054
14	Cayuga (Trinity),[2] *Anderson*	1938	40	611,004 32,962	100,804 5,491
15	Cedar Creek, *Limestone*	1927	30	330,600	0
16	Chapel Hill,[2] *Smith*	1938	10,000	2,345,008 1,966,402	631,438 608,644
17	Chatfield,[1] *Navarro*	1905	0	0	0
18	Coke, *Wood*	1942	1,200	1,354,326	814,219
19	Collinsville, *Grayson*	1938	100	36,694	924
20	Concord, *Anderson*	1942	20	15,587	444
21	Corsicana,[6] *Navarro*	1895	6,710	14,846,359	128,095
22	Currie,[7] *Navarro*	1921	475	7,004,775	28,432
23	DeBerry, *Panola*	1926	100	29,166	0
24	East Texas,[2] *Cherokee, Gregg, Rusk, Smith, Upshur*	1930	136,000	13,682 2,095,280,126	466 134,768,033
25	Eylau, *Bowie*	1944	40	2,744	2,744
26	Flag Lake, *Henderson*	1937	405	599,805	23,433
27	Fruitvale, *Van Zandt*	1944	80	12,856	12,856
28	Ginter, *Angelina*	1936	60	47,084	4,800
29	Grapeland,[2] *Houston*	1936	40	7,815,150 136,100	1,065,083 0
30	Groesbeck, *Limestone*	1913 1924 1941	x x 10	x x 5,720	x x 2,463
31	Groesbeck, *West, Limestone*	1944	20	x	x
32	Hawkins,[2] *Wood*	1940	8,350	16,228 34,439,795	773 13,317,088
33	Hemby (Elkhart),[1] *Anderson*	1938	0	4,012	0
34	Henderson,[2] *Rusk*	1943	400	12,206 70,216	10,668 60,109
35	Huntington, *Angelina*	1936	100	14,898	435
36	Joaquin,[1,11] *Shelby*	1931	0	236,859	31,985
37	Kildare,[2] *Cass*	1942	1,500	3,845 1,071,128	247 517,883
38	Kosse, *Limestone*	1922	10	33,000	0
39	Larissa, *Cherokee*	1942	40	22,546	9,494
40	Lone Star, *Cherokee*	1938	120	126,723	51,952

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Condensate field.
[2] Condensate and oil field, upper figure condensate production, lower figure oil production.
[5] Includes Hull and Pulaski Ferry.
[6] Includes Mildred, Angus-Edens, Hodge, Burk-Rice, Oil Ridge and Old Powell (shallow).
[7] Includes North Currie.
[11] Field extends into Louisiana.

TABLE 1.—(*Continued*)

Line Number	Area Proved, Acres[d]	Gas Production, Millions Cu. Ft.[e], To End of 1944	Gas Production, Millions Cu. Ft.[e], During 1944	Number of Oil and/or Gas Wells[f], Completed to End of 1944	Number of Oil and/or Gas Wells[f], 1944, Completed	Number of Oil and/or Gas Wells[f], 1944, Abandoned	Wells Producing[g] Dec. 1944, Oil, Flowing	Wells Producing[g] Dec. 1944, Oil, Artificial Lift	Wells Producing[g] Dec. 1944, Gas	Reservoir Pressure, Lb. per Sq. In., Initial	Reservoir Pressure, Lb. per Sq. In., Avg./End 1944	Secondary Recovery[h]	Character of Oil[i], Gravity A.P.I. at 60°F.	Character of Oil[i], Sulphur, Per Cent
1	20	x	x	1	0	0	0	0	1	x	x		52	x
2	300	6,776	2,744	8	1	0	0	0	8	2,659	x		61	x
3	20	x	x	9	0	2	1	5	0	1,300	x		42	x
4	0	x	0	1	0	0	0	0	0	x	x		24	x
5	0	x	x	33	0	0	1	15	0	1,680	x		38	x
6	200	x	x	10	0	1	0	0	0	x	x		40	x
7	0	x	x	59	0	7	0	28	0	x	x		41	x
8	7,500	11,459	1,488	10	0	0	0	0	9	2,502[3] 2,620[4]	x x		48 25	x x
9	0	x	x	1	1	0	0	1	0	x	x		38	x
10	0	x	0	10	0	0	0	0	0	1,950	x		41	x
11	0	x	x	2	0	0	0	2	0	1,830	x		32	x
12	190,000	48,037	21,619	38	13	0	1	0	35	x	x		x 55 64 41	x x x x
13	10,900	168,415	19,482	336	0	36	60	164	58	1,750	1,221	C	63 29	x x
14	x	27,962	2,916	9	3	0	1	0	8	3,525	2,490	P	57	x
15	0	x	0	14	0	0	0	0	0	x	x		37	x
16	3,700	41,805	12,781	66	0	1	41	5	19	2,574 3,700 4,000	x x x		74 63 43	x x x
17	150	4,750	0	15	0	0	0	0	0	250	x		Gas	x
18	0	129	57	30	0	1	17	12	0	2,705	2,665		26	2.3
19	0	x	x	2	0	0	0	1	0	x	x		29	x
20	0	x	x	1	0	1	0	0	0	1,620	x		12	x
21	x	x	x	1,442[6]	0	17	0	590[6]	0	x	x		27	x
22	0	x	x	55	0	1	0	12	0	x	x		40	x
23	50	x	x	22	0	0	0	0	0	757	x		46	x
24	2,000	785,987[8]	48,379[8]	27,387	0	479	15,530	8,617	4	1,620	1,002		58 39	x x
25	0	x	x	1	1	0	0	1	0	3,550	x		39	x
26	40	x	x	26	0	4	0	7	1	1,394	x		45	x
27	0	x	x	2	2	0	0	2	0	x	x		39	x
28	0	x	x	4	0	0	0	4	0	x	x		21	x
29	6,500	49,384	12,883	43	1	0	0	0	34	2,535	x	C	63 43	x x
30	2,360	x	x	30	0	0	0	0	0	275	x		Gas	x
	60	x	x	5	0	0	0	0	0	875	x		Gas	x
	x	x	x	1	0	0	0	1	0	x	x		41	x
31	0	0	0	1	1	0	0	1	0	x	x		41	x
32	4,850	1,839	96	417	10	x	375	26	4	1,990[9]	1,800		25	1.6
33	100	1,162	0	2	0	0	0	0	1	2,200	x		59	x
34	80	223	180	5	3	0	4	0	1	1,900	x		43	x
35	0	x	x	12	0	0	0	1	0	x	x		24	x
36	6,000	56,393	12,364	27	0	0	0	0	10	2,550	x	C	48	x
37	100	301	19	35	5	0	24	9	2	2,750	x		41	x
38	0	x	x	1	0	0	0	0	0	x	x		32	x
39	0	x	x	1	0	0	1	0	0	x	x		48	x
40	0	x	x	5	1	0	1	2	0	1,375	x		35	x

[3] South dome.
[4] North dome.
[8] Includes estimates of gas produced with oil and gas produced from gas wells.
[9] Corrected to 4075 ft. subsea.

TABLE 1.—(*Continued*)

Line Number	Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
1	Travis Peak, CreL	S	P	8,610	30	A	Travis Peak	9,295
2	L. Glen Rose, CreL	L	15	5,584	25	AF	Travis Peak	6,051
3	Woodbine, CreU	S	23	2,992	15	AF	Woodbine	3,008
4	Queen City, Eoc	S	P	2,045	5	ML	Carrizo	2,324
5	Woodbine, CreU	S	25	3,632	34	DS	Fredericksburg	4,648
6	Cisco, Pen	SL	P	1,630	25	AF	Ellenburger	2,530
7	Basal Walnut, CreL	L	P	450	3	AF	Trinity	1,800
8	Woodbine, CreU	S	20	5,273 5,634	22[3] 44[4]	D	Washita	6,300
9	Nacatoch (Basal Navarro) CreU	S	P	2,181	11	F	Edwards Lime	5,022
10	Sub-Clarksville (Eagle Ford) Woodbine, CreU	S	P	5,054	5	AF	L. Glen Rose	8,383
11	Paluxy, CreL	S	15	4,350	10	AF	Glen Rose	4,800
	Hill Sand, CreL	S	P	4,906	Gas 14	D		
12	L. Glen Rose (U. Pettit), CreL	OL	19	4,984	Gas 20	MC	Cotton Valley	9,306
	L. Glen Rose (L. Pettit), CreL	L	23	5,930	Gas 10	D		
	Travis Peak, CreL	S	P	6,230	Oil 8	D		
13	Woodbine, CreU	S	25	3,680	Gas 54 Oil 24	AF	Trinity	9,085
14	L. Glen Rose, CreL	L	20	7,600	10	AF	Trinity	9,085
15	Woodbine, CreU	S	25	2,885	10	AF	Woodbine	3,310
	Paluxy	S	23	5,600	50			
16	L. Glen Rose (Rodessa) CreL	OL	10–18	7,400	25	A	Travis Peak	8,600
	L. Glen Rose (Pettit) CreL	OL	10–18	8,000	24			
17	Corsicana (Wolfe City) CreU	S	P	880	13	A	Woodbine	3,057
18	Paluxy, CreL	S	21	6,300	55	A	Travis Peak	8,901
19	Strawn, Pen	S	P	3,848	20	ML	Strawn	4,219
20	Woodbine, CreU	S	25	4,522	10	D	Salt	6,327
21	Nacatoch (Wolfe City) CreU	S	P	800	12 20	AF	Woodbine	3,570
22	Woodbine, CreU	S	22	2,930	20	AF	Woodbine	3,646
23	Blossom (Glen Rose) CreU	S, Sh	P	1,990	*x*	ML	Blossom	2,125
24	Woodbine, CreU	S	25	3,632	35	S[10]	Paluxy	5,020
25	Smackover, Jur	OL	P	7,658	*x*	D	Smackover	7,716
26	Woodbine, CreU	S	23	3,075	5	AF	Travis Peak	6,518
27	Travis Peak, CreL	S	P	8,550	18	D	Travis Peak	9,002
28	Carrizo, Eoc	S	P	2,186	10	ML	Wilcox	2,265
29	Woodbine, CreU	S	25	5,976	25	A	Woodbine	6,300
	Nacatoch, CreU	S	25	710	40			
30	Woodbine, CreU	S	20	2,945	15	AF	L. Glen Rose (Pettit)	5,796
	L. Glen Rose (Pettit) CreL	L	P	5,685	*x*			
31	U. Glen Rose, CreL	L	P	4,734	*x*	F	L. Glen Rose (Pettit)	5,501
32	Sub-Clarksville (Gas)	S	P	3,910	80	AF	Paluxy	6,535
	Woodbine (Oil) CreU	S	30	4,475	160			
33	Woodbine, CreU	S	25	5,409	*x*	AD	Woodbine	5,487
34	L. Glen Rose (Pettit) CreL	L	P	7,250	14	A	Pettit	7,494
35	Queen City, Eoc	S	*x*	1,458	8	ML	Mount Selman	1,490
36	U. Glen Rose, CreL	L	*x*	4,097	10	D	Glen Rose	5,128
	L. Glen Rose, CreL	L	*x*	5,070	30			
37	L. Glen Rose (Gloyd) CreL	L	16	5,973	Gas 25 Oil 15	AF	L. Glen Rose (Dees-Young)	6,205
38	Unknown	*x*	*x*	*x*	*x*	Crev	Glen Rose	6,056
39	L. Glen Rose (Pettit) CreL	OL	P	10,163	*x*	AD	Travis Peak	10,604
40	Woodbine, CreU	S	P	4,006	4	AF	Woodbine	4,015

[10] "S" indicates shore line.

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944
41	Long Lake,[2] *Anderson, Freestone, Leon*	1933	5,800	6,957,994 8,797,825	1,172,702 1,749,718
42	Long Lake, East,[2] *Anderson*	1941	300	174 534,994	174 210,116
43	Lott, *Falls*	1937	*x*	31,899	0
44	Manziel,[2] *Wood*	1943	1,130	1,150 559,106	1,150 478,538
45	Marion County (shallow)	1939	670	384,610	44,789
46	Marlin-Satin, *Falls*	1931	10	12,830	0
47	Merigale, *Wood*	1944	40	730	730
48	Mexia, *Limestone*	1920	3,920	99,404,720	500,523
49	Mexia (shallow),[1] *Limestone*	1912	0	0	0
50	Mount Calm, *Hill*	1929	*x*	27,991	0
51	Nacogdoches,[12] *Nacogdoches*	1865	1,000	437,256	1,062
52	Navarro Crossing,[2] *Houston*	1938	1,040	2,515 894,852	140 83,036
53	New Hope, *Franklin*	1943	3,000	1,125,695	1,007,091
54	Nigger Creek, *Limestone*	1926	170	2,999,466	0
55	Oakwood,[2] *Leon*	1939	80	231 14,331	0 0
56	Opelika,[2] *Henderson*	1937	*x*	6,309,599 19,314	1,426,880 0
57	Panola (Bethany),[2,11] *Panola*	1921	60	74,262 76,416	23,677 6,080
58	Percilla,[2] *Houston*	1937	10	4,398 29,551	2,678 0
59	Pickering, *Shelby*	1941	20	948	0
60	Pickton, *Hopkins*	1944	40	8,147	8,147
61	Pittsburgh, *Camp*	1940	1,500	641,856	357,696
62	Pleasant Grove, *Rusk*	1941	200	219,590	73,958
63	Pleasant Grove (shallow), *Rusk*	1941	40	22,456	5,445
64	Post Oak (Chilton), *Falls*	1922	100	178,983	0
65	Potter (Caddo),[11] *Marion*	1905	980	7,746,795	19,661
66	Pottsboro, *Grayson*	1928	200	13,107	303
67	Powell,[15] *Navarro*	1923	2,600	112,723,779	475,132
68	Quitman, *Wood*	1942	2,200	2,723,349	2,072,785
69	Redland, *Angelina*	1939	10	60	0
70	Red Lake,[2] *Freestone*	1934	10	2,409 1,605	493 0
71	Richland, *Navarro*	1924	440	6,689,449	9,282
72	Rodessa (Dees-Young),[2,11] *Cass*	1935	5,010	32,133,319[16]	1,049,006[16]
73	Rodessa (Hill-Gloyd),[2,11] *Cass*	1936	1,885	9,760,854[16]	275,907[16]
74	Rodessa (Hill-Henderson-Gloyd),[2] *Marion*	1937	4,035	13,424,895[16]	396,971[16]
75	Rodessa,[2,11] total		10,930	55,319,068[16]	1,721,884[16]
76	Rowe and Baker, *Henderson*	1939	80	82,412	0
77	Rusk, *Cherokee*	1934	200	261,134	0
78	Sadler, *Grayson*	1943	20	546	380
79	Sand Flat, *Smith*	1944	300	56,339	56,339
80	Shelbyville, *Shelby*	1917	50	18,348	1,809
81	Sulphur Bluff, *Hopkins*	1936	855	12,503,771	1,418,921
82	Tacoma, *Panola*	1933	40	15,750	0
83	Talco, *Franklin, Titus*	1936	7,850	75,521,356	8,673,189
84	Tehuacana, *Limestone*	1940	60	50,049	3,522
85	Tri-Cities,[1] *Henderson*	1941	*x*	127,530	26,772
86	Trinity, *Houston*	1934	120	2,213,894	166,068
87	Tundra, *Van Zandt*	1944	40	235	235

[12] Includes Chireno and Jennings fields.
[15] Includes shallow production discovered and produced since 1923 in the Powell Woodbine producing area.
[16] Production by horizons estimated. Includes distillate production.

TABLE 1.—(*Continued*)

Line Number	Gas Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]	
	Area Proved, Acres[d]	Millions Cu. Ft.[e] To End of 1944	Millions Cu. Ft.[e] During 1944	Completed to End of 1944	1944 Completed	1944 Abandoned	Oil Flowing	Oil Artificial Lift	Gas	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent
41	10,000	116,747	18,978	242	5	4	110	39	89	2,440	2,090	C	63 41	x x
42	80	11	11	16	4	0	12	3	1	x	x		43	x
43	0	x	0	5	0	0	0	0	0	x	x		29	x
44	x	30	30	29	19	0	18	11	0	x	x		34	x
45	0	x	x	45	0	2	0	35	0	x	x		42	x
46	0	x	0	2	0	0	0	0	0	x	x		34	x
47	0	x	x	1	1	0	0	1	0	x	x		26	x
48	x	x	x	574	1	12	0	176	0	x	x		35	x
49	4,094	20,200	0	50	0	0	0	0	0	276	x		Gas	x
50	0	x	0	2	0	0	0	0	0	x	x		31	x
51	x	x	x	50	0	0	0	38	0	x	x		23	x
52	3,450	11,646	232	31	0	0	14	6	2	2,670	x		41 37	x x
53	x	x	x	27	24	0	27[13]	0	0	3,425 3,523 3,750 3,750	x x x x		42 47 49 52	x x x x
54	0	x	0	75	0	0	0	0	0	x	x		40	x
55	1,000	51 x	0 0	6	0	0	0	0	0	x	x		36	x
56	7,300	45,960	11,631	16	2	0	0	0	14	3,845 x x	x x x	C	59 39 x	x x x
57	23,000	162,390	3,451	355	1	7	0	4	46	2,470	2,220		60 28	x x
58	200	954	115	3	0	0	0	0	1	x	x		41	x
59	0	x	0	1	0	0	0	0	0	x	x		40	x
60	0	x	x	1	1	0	1	0	0	x	x		50	x
61	0	x	x	23	14	0	0	23	0	3,408	2,100		39	x
62	0	x	x	8	0	0	2	5	0	x	x		40	x
63	0	x	x	1	0	0	0	1	0	x	x		35	x
64	0	x	0	26	0	0	0	0	0	x	x		33	x
65	0	x	x	78	0	3	0	24	0	x	x		40	x
66	0	x	x	15	0	0	0	1	0	300	x		39	x
67	x	x	x	770	0	2	0	150	0	800	x		38	x
68	0	x	x	59	10	0	52	7	0	2,745	2,600		41	1.1
69	0	x	0	1	0	0	0	0	0	x	x		23	x
70	400	2,442	352	3	0	0	0	0	2	2,102	x		x	x
71	x	x	x	101	0	0	0	4	0	x	x		38	x
72	3,250	123,185	5,700	298	0	6	22	174	9	2,700	x		43	x
73	10,150	45,827	2,787	89	0	3	14	29	5	2,700	x	P	42	x
74	10,150	59,932	5,525	181	0	4	25	56	16	2,677	x		42	x
75	23,550	228,944	14,012	568	0	13	61	259	30					
76	0	x	0	4	0	0	0	0	0	x	x		32	x
77	0	x	0	5	0	0	0	0	0	x	x		42	x
78	0	x	x	1	0	0	1	0	0	x	x		25	x
79	x	x	x	6	6	0	4	2	0	x	x		28 41	x x
80	0	x	x	2	0	0	0	1	0	x	x		38	x
81	0	x	x	73	0	0	0	73	0	1,900	x		23	x
82	0	x	0	3	0	0	0	0	0	x	x		46	x
83	0	x	x	821	0	10	7	706	0	1,920	x		21	x
84	0	x	x	8	0	0	0	3	0	x	x		21	x
85	2,560	626	550	5	1	0	0	0	5	3,650	x		60	x
86	0	x	x	20	0	1	2	13	0	870	x		24	x
87	0	x	x	1	1	0	1	0	0	x	x		44	x

[13] Dual oil completions.

TABLE 1.—(*Continued*)

Line Number	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
41	Woodbine, CreU	S	25	5,170	{24 8}	A	Trinity	10,686
42	Woodbine, CreU	S	24	5,335	8	D	Woodbine	5,417
43	Buda (U. Washita) CreL	DL	P	1,250	10	AF	Edwards	1,500
44	Paluxy, CreL	S	P	6,244	15	AF	Travis Peak	8,768
45	Tokio, CreU	S	P	2,336	10	A	Tokio	2,346
46	Buda, CreL	L	20	1,000	20	AF	Glen Rose	1,429
47	Sub-Clarksville, CreU	S	P	4,850	25	F	Woodbine	6,100
48	Woodbine, CreU	S	25	3,000	50	AF	CreL or Older	8,847
49	Nacatoch, CreU	S	25	710	40	AF	CreL or Older	8,847
50	Austin, CreU	C	P	607	8	F	Travis Peak	3,398
51	Weches, Eoc	S	P	80	x	ML	CreL	5,484
52	Woodbine, CreU	S	24	{5,750 5,874}	Gas 31 Oil 7	DF	Woodbine	5,968
53	L. Glen Rose (Bacon) CreL L. Glen Rose (Hill) CreL L. Glen Rose (Pittsburgh) CreL L. Glen Rose (Elledge) CreL	OL S S S	15 x 13 15	7,323 7,432 7,898 7,997	16 x 50 30	A	Travis Peak	8,300
54	Woodbine, CreU	S	25	2,820	15	AF	Woodbine	3,509
55	Woodbine, CreU	S	P	5,838	3	D	Woodbine	5,913
56	U. Glen Rose, CreL L. Glen Rose (Rodessa) CreL Travis Peak, CreL	LS LS LS	19 20 15	7,195 8,200 9,194	Oil 40 Gas 42 Gas 100	AF	Travis Peak	9,740
57	Various,[14] CreU, CreL	S, L	P	1,100	40	A	Salt	11,303
58	Woodbine, CreU	S	P	{5,932 5,665}	Gas 6 Oil 5	A	Del Rio	6,634
59	Nacatoch, CreU	S	P	1,475	20	ML	Washita	3,343
60	L. Glen Rose (Bacon) CreL	L	P	7,888	15	D	Travis Peak	8,853
61	Pittsburgh (Travis Peak) CreL	S	16	7,948	20	D	Travis Peak	8,551
62	Woodbine, CreU	S	20	4,055	5	F, S[10]	Woodbine	4,372
63	Nacatoch, CreU	S	P	2,910	25	F, S[10]	Woodbine	4,372
64	Buda, CreL	L	P	1,025	10	AF	Trinity	3,567
65	{Nacatoch, CreU Tokio, CreU	S S	P 20	1,025 2,300	x 15	A	Tokio	2,400
66	Trinity (Basal), CreL	S	P	830	8	MU	Ordovician or Older	6,004
67	Woodbine, CreU	S	25	2,925	40	AF	Trinity	6,506
68	Paluxy, CreL	S	21	6,250	35	AD	Paluxy	6,781
69	Wilcox, Eoc	S	P	1,021	8	ML	Wilcox	1,032
70	Woodbine, CreU	S	20	4,850	25	AF	Woodbine	5,002
71	Woodbine, CreU	S	25	2,975	20	AF	Glen Rose	5,414
72	L. Glen Rose (Dees-Young) CreL	L	17	5,794	25	AF		
73	L. Glen Rose (Hill-Gloyd) CreL	S, L	16	5,914	20	AF		
74	L. Glen Rose (Hill-Henderson-Gloyd) CreL	S, L	15	6,044	20	AF		
75							Salt, CreL or Older	11,484
76	Woodbine, CreU	S	20	3,140	6	AF	Woodbine	3,149
77	Woodbine, CreU	S	20	5,120	10	MU	Woodbine	5,302
78	Strawn, Pen	S	P	7,160	10	M	Simpson	8,403
79	Paluxy, CreL Rodessa, CreL	S L	21 P	7,013 9,342	25 20	DF	Travis Peak	10,011
80	Blossom, CreU	S, L	P	3,196	10	ML	Georgetown	3,520
81	Paluxy, CreL	S	25	4,487	36	AF	Glen Rose	6,600
82	Blossom, CreU	S	P	2,073	10	ML	Blossom	2,302
83	Paluxy, CreL	S	20	4,200	35	AF	Smackover	9,048
84	Woodbine, CreU	S	P	2,640	10	AF	Georgetown	2,825
85	L. Glen Rose (Rodessa) CreL	L	P	7,608	20	A	Travis Peak	8,474
86	Carrizo, Eoc	S	25	1,987	25	Ds	Wilcox	5,500
87	Glen Rose, CreL	L	18	8,145	5	F	Glen Rose	8,160

[14] Nacatoch 1100 ft., gas; Buckrange, 1700, oil; Barlow, 2300, gas; Adams, 2650, gas; Tiller (Paluxy), 2300, gas; Werner, 3600, gas; Jeter (Glen Rose), 5700, gas; Pettit, gas.

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Oil Production		
			Area Proved, Acres[b]	Total Production, Bbl.[e] To End of 1944	Total Production, Bbl.[e] During 1944
88	Tyler, South, *Smith*	1944	40	33,110	33,110
89	Van (deep), *Van Zandt*	1929	4,520	150,725,614	11,612,221
90	Van (shallow), *Van Zandt*	1933	200	377,014	23,487
91	Van, total		4,720	151,102,628	11,635,708
92	Waskom,[2,11] *Harrison*	1924	1,500	{ 529,998 129,648	147,584 13,121 }
93	Weiland, *Hunt*	1942	250	292,512	156,823
94	Willow Springs,[3] *Gregg*	1938	40	{ 618,727 2,065	155,845 0 }
95	Winnsboro, *Wood*	1944	80	23,558	23,558
96	Witherspoon-McKie, *Navarro*	1915	400	810,495	0
97	Wortham,[17] *Freestone*	1924	715	23,173,263	102,149
98	Grand total		229,740	{ 28,962,014 2,763,434,239	5,515,158 184,501,022 }

[17] Wortham (shallow) discovered in 1912 included with Wortham.

Line Number	Gas Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944			Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]	
	Area Proved, Acres[d]	Millions Cu. Ft.[e] To End of 1944	Millions Cu. Ft.[e] During 1944	Completed to End of 1944	1944 Completed	1944 Abandoned	Oil Flowing	Oil Artificial Lift	Gas	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent
88	0	x	x	1	1	0	1	0	0	x	x		46	x
89	60	x	x	582	0	0	303	262	2	1,230	1,045		34	x
90	200	x	x	42	2	1	0	28	0	x	x		31	x
91	260	x	x	624	2	1	303	290	2					
92	7,280	132,509	8,120	248	0	0	0	17	18	{ x 2,268 2,660	x x x		35 59 59	x x x
93	0	x	x	10	3	0	0	10	0	1,242	x		36	x
94	6,500	45,184	13,501	11	1	0	0	0	9	3,468	x	C	{ x 57 38	x x x
95	0	x	x	2	2	0	1	1	0	3,660	x		48	x
96	0	x	0	85	0	0	0	0	0	x	x		19	x
97	0	x	x	341	0	4	0	26	0	x	x		{ 29 37	x x
98	324,604	1,972,316	205,991	35,634	141	609	16,674	11,435	414					

TABLE 1.—(*Continued*)

Line Number	Producing Formation: Name and Age[f]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
88	L. Glen Rose (Pettit) CreL	L	P	9,870	60	D	Travis Peak	10,017
89	Woodbine, CreU	S	P	2,682	129	AF	Travis Peak	7,501
90	Nacatoch, CreU	S	P	1,200	20	AF	Travis Peak	7,501
91								
	Nacatoch, CreU	S	P	800	x			
92	Blossom, CreL	S, L	P	x	15	A	Travis Peak	6,490
	Glen Rose, CreL	L		6,282	40			
93	Woodbine, CreU	S	33	2,750	14	AF	Eagle Mills	9,523
	L. Glen Rose (Rodessa) CreL	OL	x	6,768	Gas 2			
94	L. Glen Rose (Pettit) CreL	OL	20	7,244	Gas 35	D	Cotton Valley	10,284
	L. Glen Rose (Pettit) CreL	OL	x	7,298	Oil 10			
95	L. Glen Rose, CreL	L	P	7,995	10	AF	Travis Peak	8,719
96	Nacatoch, CreU	S	14	825	19	AF	Woodbine	3,480
97	Nacatoch, CreU	S	x	1,361	6	AF	Glen Rose	4,825
	Woodbine, CreU	S	25	2,990	35			
98								

TABLE 2.—*Summary of Drilling Operations in East and East Central Texas*

Discoveries, Extensions, and Important Wildcats Drilled during 1944

Line Number	County	Drilled by	Well No. and Farm	Survey	Producing Formation: Name	Producing Formation: Depth of Top, Ft.
1	Anderson............	Magnolia Petroleum Co.	1, H. Horwitz	J. B. McNeely		
2	Angelina............	Humble Oil & Ref. Co.	1, Angelina Lumber Co.	W. R. Wood		
3	Bowie............	Barnsdall Oil Co.	2, Louis Heilborn	M. H. James	Smackover	7,714
4	Bowie............	Barnsdall Oil Co.	1, Gifford-Hill	M. H. James		
5	Hopkins............	Humble Oil & Ref. Co.	1, C. B. Nichols	I. Friddle	Bacon lime	7,888
6	Hopkins............	Onyx Refining Co.	1, Ira Cundiff	S. Derrick		
7	Houston............	Ivy & Moran	2, G. L. Murray & Sons	J. Durst		
8	Houston............	Grapeland Oil Co.	1, J. M. Horn Est.	J. Herrod	Woodbine	6,015
9	Hunt............	Humble Oil & Ref. Co.	1, E. M. Anderson	J. Porter		
10	Hunt............	Humble Oil & Ref. Co.	1, Lessa Norman	H. Thompson		
11	Limestone............	Zephr Oil Co.	1, Nuessbaum & Scharff	S. H. Bates	U. Glen Rose	4,788
12	Morris............	Humble Oil & Ref. Co.	1, H. N. Wright	S. Story		
13	Navarro............	Brown & Wheeler	1, G. M. Gibson	J. Fontnoy		
14	Panola............	Rogers Lacy	1, Cameron Lumber Co.	Wm. A. Lagronne	Upper Pettit Travis Peak	5,786 6,230
15	Red River............	The Texas Co.	1, H. O. Solomon	W. E. Edwards		
16	Robertson............	Hammon Oil Co.	1, P. C. Gibson	Jesse Webb	Nacatoch	2,181
17	Robertson............	A. G. Hill and Magnolia Petr. Co.	1, W. C. Anderson	Joseph Webb		
18	Smith............	Skelly Oil Co.	1, Chism et al.	D. Minor	Paluxy	6,972
19	Smith............	Phillips Petroleum Co.	1, W. J. McMinn	Mary Long	Pettit	9,918
20	Smith............	Sun Oil Co.	1, Mrs. Alice Patterson	Felix Flores	Rodessa	9,342
21	Van Zandt............	Superior Oil Co.	1, C. A. Groves	E. Van Sickle	Travis Peak	8,552
22	Van Zandt............	The Texas Co.	1, J. F. Stout	N. T. Dickerson	Rodessa	8,145
23	Wood............	Magnolia Petroleum Co.	1, Sallie McGee	A. Gonzales		
24	Wood............	Manziel	1, V. L. Evans	J. Starks	Sub-Clarksville	4,850
25	Wood............	Gulf Oil Corporation	1, K. C. Brewer et al.	B. Lea	Rodessa	7,995

TABLE 3.—*Production Statistics, East Texas Field*[a]

Date, Year 1944	Average Reservoir Pressure at −3300 Ft., Lb. per Sq. In.	Production, Bbl. (42 U. S. Gal.)	Number of Days Shut Down
Jan. 1	1,012.44	11,340,057	8
Feb. 1	1,010.20	11,304,513	6
Mar. 1	1,003.47	11,313,308	8
Apr. 1	1,008.50	10,815,307	8
May 1	1,011.26	11,258,880	8
June 1	1,012.29	10,574,115	8
July 1	1,009.97	11,194,243	8
Aug. 1	1,006.24	11,602,662	7
Sept. 1	1,007.88	11,143,694	7
Oct. 1	1,001.61	11,589,709	7
Nov. 1	998.33	11,094,723	7
Dec. 1	1,001.63	11,536,822	7
Average and total	1,006.99	134,768,033	89

[a] Data from Texas Railroad Commission.

Hawkins field has proved to be the most important discovery in the district since the East Texas field was discovered.

The East and East Central district is still one of the most prolific in the state and accounted for 26 per cent of the Texas production for 1944 with 741,116,077 barrels.

Salt-water injection activity decreased in the East Texas field toward the end of 1944 by the removal of water-producing leases from production. However, injected volumes increased slightly to 357,294 bbl. per day at the end of 1944 from 306,811 bbl. per day at the end of 1943. In general, the extent of the effect of the salt-water injection program is still not

TABLE 2.—(*Continued*)

Discoveries, Extensions, and Important Wildcats Drilled during 1944

Line Number	Deepest Horizon Tested	Total Depth, Ft.	Initial Production per Day			Gravity of Oil, Deg. A.P.I.	Choke or Bean Size, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
			Oil, U. S. Bbl.	Gas, Thousands Cu. Ft.	Water, Bbl.			Casing	Tubing	
1	Georgetown	6,327								Dry hole. Top of salt 6002 ft., Concord field
2	Georgetown	7,212								Dry hole. Woodbine Pinchout test, 8 ft. sand
3	Smackover	7,716	155	1,250		39	1/4	1,200	1,300	Discovery well, Eylau field First Smackover prod.
4	Eagle Mills	7,836								Dry hole
5	Travis Peak	8,853	620	837		50	1/4	1,825	1,710	Discovery well, Pickton field
6	Paluxy	4,817								Dry hole, test of Peerless fault
7	Woodbine	8,507								Dry hole, most southerly Woodbine test
8	Pettit	11,074		75,000				2,150		Deep test, Grapeland field, dry gas
9	Paleozoic	6,271								Dry hole, Smackover Pinchout test
10	Smackover	7,154								Dry hole, Smackover Pinchout test
11	Pettit	5,501	39		24	41	Pump			Discovery well, Groesbeck, West, field
12	Smackover	11,810								Dry hole
13	Travis Peak	7,526								Dry hole
14	Travis Peak	6,750	3,640 (dist.) 27 (Oil)	182,000		41	3/64 19/64	2,750	122	First oil in Carthage gas field
15	Smackover	6,152								Dry hole, Smackover Pinchout test
16	Edwards Lime	5,022	70			38	Pump	100	25	Discovery well, Calvert field
17	Smackover	10,288								Dry hole, most southwesterly Smackover test
18	Travis Peak	10,011	133			28	3/16		100	Discovery well, Sand Flat field, Paluxy pay
19	Pettit	10,017	281	1,700		46	19/64		4,646	Discovery well, Tyler, South, field
20	Rodessa	9,418	24		46	41	Pump			Rodessa pay discovery well, Sand Flat field
21	Travis Peak	9,002	70			39	Pump			Discovery well, Fruitvale field
22	Rodessa	8,160	25		11	44	7/64		900	Discovery well, Tundra field
23	Travis Peak	9,076								Dry hole
24	Woodbine	6,100	32	9		26	Pump			Discovery well, Merigale field
25	Travis Peak	8,719	231			48	5/16	1,250		Discovery well, Winnsboro field

TABLE 4.—*Oil-recovery Data on Older Woodbine Fields as of January 1, 1945*

Field	County	Cumulative Production, Bbl.	Proved Acres	Net Thickness, Ft.	Acre-feet	Cumulative Production, Bbl. per Acre-ft.
Boggy Creek	Anderson, Cherokee	5,220,898	960	34	32,640	160
Cayuga	Anderson, Freestone, Henderson	32,011,691	5,500	24	132,000	243
Currie	Navarro	7,004,775	475	20	9,500	737
East Texas	Cherokee, Gregg, Rusk, Smith, Upshur	2,095,280,126	136,000	35	4,760,000	440
Flag Lake	Henderson	599,805	405	5	2,025	296
Mexia	Limestone	99,404,720	3,920	50	196,000	507
Powell	Navarro	112,723,779	2,600	40	104,000	1,084
Richland	Navarro	6,689,449	440	20	8,800	760
Van (Deep)	Van Zandt	151,102,099	4,520	129	583,080	259
Wortham	Freestone	23,173,263	715	35	25,025	926
Cedar Creek[a]	Limestone	330,600	30	10	300	1,102
Nigger Creek[a]	Limestone	2,999,466	170	15	2,550	1,176
Rusk[a]	Cherokee	261,134	200	10	2,000	131

[a] Abandoned fields.

well defined. The reservoir pressure drop for the year was approximately 10 lb., a slight increase in drop over the preceding year, probably because of the increased rate of oil production.

Pipe Lines

Construction of pipe lines during 1944 consisted principally of short connecting lines. The Gulf Pipe Line Co. completed four such lines. The only major construction in the area was the portion of Magnolia Pipe Line Company's 12-in. line from Midland, Texas, terminating at Corsicana. The pipe-line activity of the area is shown in Table 5.

Acknowledgments

The authors wish to acknowledge the assistance of the many persons who contributed information and effort in the compilation of this report: C. V. Millikan, of the Amerada Petroleum Co., Tulsa; Wm. L. Horner, Barnsdall Oil Co., Tulsa; P. A. Robertson, Gulf Oil Corporation, Houston; J. S. Hudnall, Tyler, Texas;

TABLE 5.—*Pipe-line Construction in East and East Central Texas during 1944*

Company	Origin	Terminal	Length, Miles	Size, In.	Remarks
Magnolia Pipe Line Co.	Midland, Texas	Corsicana, Texas	336	12	Parallel to Magnolia's 8-in. Approximately 21 miles on eastern end in district 6.
Lone Star Gas Co.	Stewart's Mill gas field	½ mile north of Wortham	14½	6	To Lone Star's main line
Sohio Petroleum Co.	Manziel field	Coke field	4	4	To deliver Manziel crude to Talco pipe line, Coke field, to be moved as common carrier to Mt. Pleasant for tank cars
Gulf Pipe Line Co.	Saltillo station	New Hope Junction	9½	8	Loop line
Gulf Pipe Line Co.	Big Sandy station	War Emergency Pipe Line, Inc.	24$\frac{3}{10}$	8	West Texas oil moves through this line from Gulf's Saltillo station to the W.E.P.L.'s Longview station
Gulf Pipe Line Co.	Pittsburgh field	Gulf's New Hope station	7½	4	Connecting Pittsburgh field to Gulf's New Hope station, thence from New Hope to Gulf's main line to Oklahoma
Gulf Pipe Line Co.	Winnsboro field	Gulf's main line	4½	4	Connecting Winnsboro field to Gulf's East Texas to Oklahoma main line

L. T. Potter, Lone Star Gas Co., Dallas; Charles T. May, Pure Oil Co., Fort Worth; Melbert Schwarz, Seaboard Oil ton, Texas; also the following Magnolia Petroleum Co. employees: Dr. Ivan Alexander, Tyler; Lloyd Hazeltine, Wichita

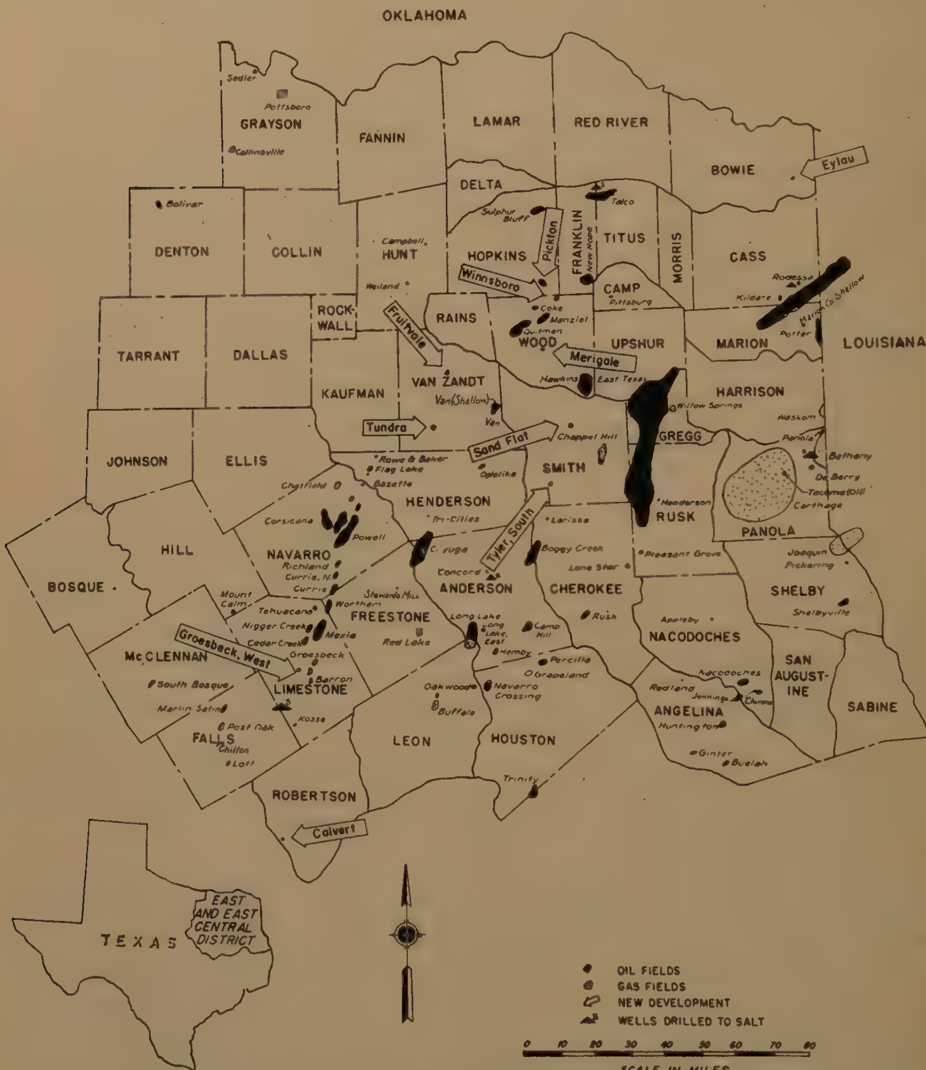

FIG. 1.—LOCATION OF OIL AND GAS FIELDS, EAST AND EAST CENTRAL TEXAS.
Texas Railroad Commission Districts 5 and 6.
A map of all Texas districts appeared in *Trans.* A.I.M.E. (1944) 155, 469.

Co., Dallas; R. M. Hess, Shell Oil Corporation, Kilgore; E. L. Rawlins, Union Producing Co., Shreveport, La.; L. A. Hancock, Magnolia Pipe Line Co., Gregg- Falls; Everett Eaves, L. T. Daniel, M. S. Priddy, Mesdames Jessie S. Myers, Grace V. Sherman, Martha A. Farrish, and Claire R. White.

Oil Production in the Upper Texas Gulf Coast during 1944

By P. B. Leavenworth,* Member A.I.M.E., and W. H. Hough*

Development in the upper Texas Gulf Coast during 1944 resulted in the discovery of 19 new fields as compared with 11 during 1943. These discoveries include 10 oil fields, one dry gas field, and eight gas-condensate fields.

Drilling

During the year 590 wells were drilled as compared with 418 drilled during 1943. Of these operations, 485 wells were drilled in proven fields, with the following results: 281 oil wells, 22 condensate wells, one dry gas well and 141 dry holes. The remaining 105 wells were wildcats, of which 19 were producers. The geological distribution of these discoveries was as follows:

Period	Oil	Condensate	Gas	Total
Miocene	0	0	1	1
Frio	7	2	0	9
Cockfield-Yegua	4	1	0	5
Wilcox	0	4	0	4

Production

In 1944, production amounted to 178,522,630 bbl., which was an increase of some 31,670,384 bbl. over the 1943 figure of 136,852,246 bbl. These figures include both condensate and oil production, as separate figures are not available.

Wildcatting in the area was more successful during 1944 than in 1943 as the following comparison of number of wells drilled illustrates:

Year	Oil	Gas Condensate	Total	Dry	Total
1943	8	3	11	79	90
1944	10	9	19	86	105

Discoveries during 1944

Smith Point, Chambers County.—Standard Oil Company of Texas completed its No. 1 State, sec. 109, on Feb. 15, 1944, in a Frio sand at 8135 to 8146 ft. The well flowed 250 bbl. of 42° gravity oil through an ⅛-in. choke. Gas-oil ratio was 800 to 1; tubing pressure, 1100 bbl. Four other oil wells and one gas well were completed during the year. This discovery does not appear to be of major importance. The producing area lies on the upthrown side of a large fault.

North Winnie, Chambers County.—Sun Oil Co. completed No. 1 P. E. Dougherty on Apr. 27, 1944, from the Frio, through perforations at 8757 to 8759 ft. The initial production was 154 bbl. of 38.3° gravity oil through an ⅛-in. choke. Gas-oil ratio was 2526 to 1; tubing pressure, 2280 lb.; casing pressure, 1225 lb.; total depth, 9519 ft. Three other wells were drilled during the year. This discovery is on the downthrown side of the major Winnie Stowell fault, and increases in magnitude the already large producing area along this fault.

Mayes Field, Chambers County.—Humble Oil and Refining Company's No. 1 Mary Etta Mayes was completed on Dec. 24, 1944, in a Frio sand, at 8166 to 8169 ft. through ¼-in. for 768 bbl. of 40.3° gravity

Manuscript received at the office of the Institute April 6, 1945.

* Gulf Oil Corporation, Houston, Texas.

TABLE 1.—*Oil and Gas Production in Upper Texas Gulf Coast*

Line Number	Field, County[a]	Year of Discovery	Oil Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944		
			Area Proved, Acres[b]	Total Production, Bbl.[e]		Completed to End of 1944	1944		Oil		Gas
				To End of 1944	During 1944		Completed	Abandoned	Flowing	Artificial Lift	
1	Abel Borden, *Wharton*	1940	T/abd.	46,945	*x*	1	0	1	0	0	0
2	Ace, Shallow, *Polk*	1934	Abd.	150,728	0	5	0	0	0	0	0
3	Ace, Deep, *Polk*	1939	250	472,802	77,856	5		0	4	1	*x*
4	Aldine, *Harris*	1939		181,353	39,882	2		0	2	0	0
5	Alief, *Harris*	1942		12,772	4,400	1	0	0	1	0	0
6	Allen, *Brazoria*	1927	Abd.	92,832	0	4	0	0	0	0	0
7	Alta Loma, *Galveston*	1940	240	869,884	171,377	6		0	6	0	0
8	Amelia, *Jefferson*	1936	1,000	10,451,666	1,690,774	98	0	0	98	0	0
9	Anahuac, *Chambers*	1935	7,000	44,455,151	11,884,831	353*x*	0	*x*	343	10	*x*
10	Angleton, *Brazoria*	1939	{(700) 40}	636,851	1,659	8	0	*x*	1	0	*x*
11	Armour, *Matagorda*	1938	125	180,753	6,357	3	0	1	0	2	0
12	Arriola, *Hardin*	1932	100	2,560,268	128,041	21	0	*x*	*x*	10*x*	0
13	Ashwood, *Matagorda*	1944	40	*x*	*x*	1	1	0	*x*	0	0
14	Bailey's Prairie, *Brazoria*	1940	Abd.	1,766	0	2	0	0	0	0	0
15	Bammell,* *Harris*	1937	2,200	999,005	40,222	20	0	*x*	1	0	*x*
16	Barbers Hill, *Chambers*	1916	500	81,387,980	2,066,008	427	1	*x*	18	107	0
17	Batson, Shallow, *Hardin*	1903	500	38,490,793	119,717	1,019	1	*x*	0	141	0
18	Batson, Deep, *Hardin*	1934	150	2,470,792	102,780			*x*	1	7	0
19	Bay City, *Matagorda*	1934	1,240	8,259,929	1,774,706	59	0	*x*	52	1	*x*
20	Beach Creek, *Hardin*	1944	40	*x*	*x*	1	1	0	1	0	0
21	Big Creek, *Ft. Bend*	1922	300	10,524,157	197,421	91*x*	0	*x*	0	15	0
22	Big Hill, *Jefferson*	1923	Abd.	14,424	0	6	0	0	0	0	0
23	Blessing, *Matagorda*	1940	Abd.	25,350	0	7	0	*x*	0	0	0
24	Blue Ridge, *Ft. Bend*	1919	500	12,195,529	193,027	228	10	*x*	10	39	0
25	Boling, *Wharton-Ft. Bend*	1925	400	8,648,483	377,602	249			11	33	0
26	Brenham, *Washington*	1915	50	388,425	2,310	37	0	0	0	6	0
27	Bryan Heights		Abd.	*x*	*x*	1	0	0	0	0	0
28	Brookshire, *Waller-Austin*	1940	Abd.	22,420	*x*	1	0	0	0	0	0
29	Buckeye, *Matagorda*	1932	200	892,909	17,662	5	0	0	4	0	0
30	Buck Snag, *Colorado*	1942	40	17,520	3,937	1	0	0	1	0	0
31	Buttermilk Slough, *Matagorda*	1939	Abd.	10,774	0	1	0	0	0	0	0
32	Call, *Newton*	1937	Abd.	11,500	0	2	0	0	0	0	0
33	Camp Eleven, *Tyler*	1942	80	286,543	120,253	2	0	0	2	0	0
34	Caplen, *Galveston*	1939	510	12,394,459	421,705	21	0	*x*	16	1	*x*
35	Cedar Bayou, *Chambers*	1938	40	25,157	2,112	1	0	0	0	1	0
36	Cedar Point, *Chambers*	1938	560	2,616,028	705,644	19		*x*	16	0	*x*
37	Cheek, *Jefferson*	1937	Abd.	72,810		3	0	0	0	0	0
38	Chenango, *Brazoria*	1941	{(120) 40}	96,146	21,786	3	0	0	1	0	0
39	Chesterville, *Colorado*	1943	100	*x*	*x*	1	0	0	1	0	Dist.
40	Chocolate Bayou, *Brazoria*	1939		634,346	98,351	13	3	0	2	0	1
41	Cistern, *Fayette*	1943	40	4,594	3,784	2	*x*	*x*	0	1	*x*
42	Clam Lake, *Jefferson*	1937	550	876,582	272,295	16	0	*x*	10	4	*x*
43	Clay Creek, *Washington*	1928	340	5,206,724	249,468	70	0	*x*	0	48	*x*
44	Clear Lake, *Harris*	1938	2,100	5,090,443	1,809,569	62	1	*x*	34	2	1*x*
45	Cleveland, *Liberty*	1933	700	1,663,640	70,213	22	1	*x*	2	4	1*x*
46	Clinton, *Harris*	1936	150	402,461	44,710	16	0	1	5	1	*x*
47	Clodine, *Ft. Bend*	1941		762,535	262,122	24	3	0	24	0	0
48	Columbus, *Colorado*	1944	40	5,775	5,775	1	1	0	1	0	*x*
49	Collegeport,*,1 *Matagorda*	1939	0	0	0	7	0	0	0	0	
50	Conroe, *Montgomery*	1931	17,660	185,163,247	23,191,757	992	1	*x*	776	124	*x*
51	Cotton Lake, *Chambers*	1936	175	1,026,175	93,807	12	0	*x*	2	6	0
52	Cottonwood, *Liberty*	1943	120	53,111	45,016	3	2	0	3	0	0
53	Daboval, *Wharton*	1944	40	2,995	2,995	2	2	0	2	0	0
54	Damon Mound, *Brazoria*	1916	260*x*	9,938,798	64,445	132	0	*x*	0	27	0

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Area proved for gas production, 10,000 acres.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
1	x	0	0	37	x	Frio, Olig	S	Por	4,758	10	x	Frio	6,557
2	x	x	0	40–53	x	Cockfield, Eoc	S	Por	4,805	10	DF	Wilcox	9,667
3	x	x	0	34–36	0.10	Wilcox, Eoc	S	Por	7,748	20	DF	Wilcox	9,667
4	x	x	0	37–66	x	Yegua, Eoc	S	34	6,662	10	D	Cook Mountain	7,664
5	x	x	0	52	x	Yegua, Eoc	S	Por	7,910	25	x	Cook Mountain	8,711
6	x	x	0	x	x	Miocene, Mio	S	Por	4,362	x	DS	Frio	12,667
7	x	x	0	34–38	x	Frio, Olig	S	Por	9,160	18	DF	Frio	11,117
8	925	x	0	27–29	x	Frio, Olig	S	Por	6,778	15	DF	Vicksburg(?) Olig	7,882
9	3,260	x	0	32	0.08	Frio, Olig	S	27	7,145	60	DF	Frio	8,749
10	x	x	0	50	x	Frio, Olig	S	Por	10,000	6	DF	Frio	11,451
11	x	x	0	33–37	x	Frio, Olig	S	Por	6,614	4	D	Frio	7,531
12	x	x	0	30–40	x	Mio and Frio, Mio-Olig	S	Por	3,000	50	DS	Vicksburg	6,743
13		x			x	Frio, Olig	S	Por	8,739	20	D	Frio	10,010
14	x	x	0	46	x	Frio, Olig	S	Por	10,535	12	x	Frio	11,860
15	x	x	0	58	x	Cockfield, Eoc	S S S	Por Por	6,170	10	D	Wilcox	10,574
16	x	x	0	25–29	x	Mio-Olig	S	Por	800	90	DS	Jackson	8,150
17	x	x	0	24–38	x	Cap rock, Mio, Olig	S	Por	245	x		Yegua	9,097
18	x	x				Yegua and Cook Mt., Eoc	S	Por	460	30			
19	x	x	0	35–36	0.087	Frio, Olig	S	27	7,023	x	D	Vicksburg	9,010
20	x	x	0	37	x	Yegua, Eoc	S	Por	6,252	18	x	Yegua	6,650
21	x	x	0	20–42	0.12	Mio, Olig	S	Por	800	21	DS	Cook Mountain	8,273
22	x	x	0	20–42	x	Mio, Olig	S	Por	1,700	20	DS	Frio	10,186
23	x	x	0	56	x	Frio, Olig	S	Por	8,290	15	DF	Frio	8,525
24	x	x	0	21–38	0.08	Mio, Frio-Mio, Olig	S	Por	1,956	55	DS	Yegua	7,979
25	x	x	0	19–33	x	Cap rock, Mio-Frio, Mio-Olig	S	Por	377	15–60	DS	Vicksburg	7,898
26	x	x	0	14–19	x	Mio	S	Por	183	x	DS	Wilcox	5,039
27	x	x	0	36	x	Mio	S	Por	3,400	20	DS	Oligocene	7,600
28	100	x	0	23	x	Olig	S	Por	2,966	16	x	Yegua	7,215
29	1,045	x	0	37–39	x	Frio, Olig	S	Por	7,761	60	D	Frio	10,503
30	x	x	0	50	x	Yegua-Eoc	S	Por	6,143	x	x	Yegua	6,997
31	1,140	x	0	45	x	Frio-Olig	S	20	7,850	10	A	Frio	9,582
32	1,475	x	0	39	x	Cockfield-Eoc	S	Por	6,908	10	D	Yegua	7,700
33	x	x	0	45	0.05	Wilcox, Eoc	S	Por	7,797	10	x	Wilcox	8,007
34	3,300	x	0	30–50	0.04	Mio	S	Por	5,975	10–40	D	Oligocene	8,009
35	x	x	0	x	x	Frio	S	Por	x	x	x	Frio	7,515
36	2,750	x	0	28–38	x	Mio, Frio, Mio, Olig	S	Por	5,943	62	D	Oligocene	8,507
37	x	x	0	44–60	x	Frio, Olig	S	Por	8,326	15	F	Oligocene	9,007
38	x	x	0	31	x	Frio, Olig	S	Por	8,564	10	D	Frio	10,497
39	x	x	0		x	Yegua, Wilcox, Eoc	S	Por	6,850 9,500	10-40	x	Wilcox	12,911
40	x	x	0	38–57	x	Frio-Olig	S	Por	9,660	16–50	DF	Frio	12,505
41	1,000	x	0		x	Recklaw, Eoc	S	Por	1,187	5	x	Wilcox	4,498
42	x	x	0	22–44	x	Mio-Mio	S	Por	2,387	15	DS	Frio	8,198
43	x	x	0	22–27	x	Miocene, Cockfield, Wilcox, Mio, Eoc	S	Por	1,224	120	DS	Midway	8,306
44	650	x	0	26–31	x	Frio-Olig	S	25	5,790	40	D	Frio	7,744
45	2,400	x	0	40	x	Cockfield and Wilcox, Eoc	S	15	5,672	8	DF	Wilcox	12,523
46	4,800x	x	0	22–48	x	Mio and Cockfield, Mio, Eoc	S	Por	3,207	20	D	Yegua	8,763
47	x	x	0	41–51	x	Yegua, Eoc	S	Por	7,460	10	D	Cook Mountain	8,300
48	x	x	0	45.8 55	x	Wilcox, Eoc			7,667 7,302			Wilcox	8,037
49	x	x	0	Gas		Miocene	S	Por		75	D	Oligocene	5,813
50	2,275	x	0	35–40	0.04	Cockfield, Eoc	S	27	5,000	30	D	Wilcox	12,020
51	x	x	0	29	x	Frio, Olig	S	Por	6,277	10	D	Vicksburg	8,580
52	x	x	0		x	Frio, Olig	S	Por	7,704	6	D	Vicksburg	8,205
53	x	x	0	46.7	x	Frio, Olig	S	Por	7,025			Vicksburg	7,445
54	x	x	0	21	x	Mio and Frio, Mio, Olig	S	Por	1,406	40	DS	Vicksburg	7,903

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Number of Oil and/or Gas Wells[f]			Wells Producing[g] Dec. 1944		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Completed to End of 1944	1944		Oil		Gas
				To End of 1944	During 1944		Completed	Abandoned	Flowing	Artificial Lift	
55	Danbury, Shallow, *Brazoria*	1934	480	1,040,503	132,518	33	4		3	11	
56	Danbury, Deep (5G55), *Brazoria*	1942	Inc. above	405,126	220,992				7	0	
57	Dickinson, *Galveston*	1934	2,700	9,210,102	538,269	127	*x*	*x*	38	16	1*x*
58	Double Bayou, *Chambers*	1943	1,500	100,264	*x*	3	1	*x*	Gas-Cond.		
59	Dyersdale, *Harris*	1940	1,200	2,093,679	701,939	63	9	*x*	51	12	0
60	El Campo, *Wharton*	1944	120	25,605	25,605	3	3	0	3	0	0
61	East Bernard, *Wharton*	1940	Abd.	1,211		1	0	0	0	0	0
62	Esperson, *Liberty*	1929	1,600	8,653,941	647,976	118		*x*	25	38	*x*
63	Esperson, South, *Liberty*	1939	Inc. above	1,572,209	265,523				23	0	*x*
64	Eureka, *Harris*	1934	900	4,364,246	471,254	39	0	*x*	7	18	*x*
65	Fairbanks, *Harris*	1938	4,000	16,830,632	2,837,079	309		*x*	264	30	*x*
66	Fannett, *Jefferson*	1927		6,478,004	1,605,222	69	7		23	12	*x*
67	Fig Ridge, *Chambers*	1940	1,500	3,587,453	2,471,546	53		*x*	53	0	*x*
68	Fishers Reef, *Chambers*	1940	100	138,593	47,368	2	0	0	2	0	0
69	Fostoria, *Montgomery*	1942	40	8,238	940	1	0	0	0	1	0
70	Fred, *Tyler*	1941	260	135,642	45,995	3	0	0	3	0	0
71	Frelsburg, *Colorado*	1944				1	1	0	1	0	0
72	Frendswood, *Harris*	1937	4,000	44,979,851	20,901,803	215	0	*x*	204	3	0
73	Garwood, *Colorado*	1932	Abd.	6,198	*x*	5	0	0	0	0	0
74	Gillock, *Galveston*	1935	2,250	11,180,208	1,364,387	99	1		68	23	*x*
75	Glasscock, *Colorado*	1944	40	*x*	*x*	1	1	0	1	0	0
76	Goodrich, *Polk*	1941	12	68,941	11,688	3	0	0	0	3	*x*
77	Goose Creek, *Harris*	1907	1,200	79,663,828	416,363	914	0	*x*	9	64	
78	Green Lake, *Galveston*	1936	225	139,597	14,108	11	0	*x*	*x*	*x*	*x*
79	Gulf (Big Hill), *Matagorda*	1904	Abd.	211,000	0	8	0	0	0	0	0
80	Halls Bayou,* *Brazoria*	1942	T/Abd.	19,197		2	0	*x*	0	0	0
81	Hamman, *Matagorda*	1936	1,100	4,686,685	335,692	30	0	*x*	3	16	*x*
82	Hampton, *Hardin*	1942	40	46,960	20,767	2	0	*x*	1	0	*x*
83	Hankamer, *Liberty*	1929	400	6,964,623	292,598	50	0	*x*	8	21	*x*
84	Hardin, *Liberty*	1935	2,750	11,260,283	1,279,353	175	0	*x*	52	72	*x*
85	Hastings, *Brazoria*	1934	5,800	85,687,396	22,166,572	693	0	*x*	648	31	*x*
86	Hawkinsville, *Matagorda*	1936	Abd.	2,000		1	0	0	0	0	0
87	High Island, *Galveston*	1922	320	20,530,251	847,506	139	0	*x*	16	42	*x*
88	Hilje, *Wharton*	1939	750	800,241	172,159	18	1	*x*	5	8	*x*
89	Hitchcock, *Galveston*	1937	250	1,389,271	185,437	15	0	*x*	6	7	*x*
90	Hockley, *Harris*	1923	Abd.	16,000	0	4	0	0	0	0	0
91	Hoskins Mound, *Brazoria*	1906	Abd.	32,000		9	0	0	0	0	0
92	Hull, *Liberty*	1918	875	99,563,702	1,630,716	823	5	*x*	12	52	0
93	Humble, *Harris*	1904	2,350	129,159,065	801,134	1,827	10	*x*	12	220	0
94	Hungerford,* *Wharton*	1944	0	Gas		1	1	0	0	0	1
95	Jackson's Pasture,* *Chambers*	1943	*x*	15,621	10,176	7	5		2	0	5
96	Joe's Lake, *Tyler*	1937	2,350	4,198,193	384,998	46	0	*x*	29	13	
97	Joyce Richardson,* *Harris*	1940	500*x*	277,191	148,713	8	3	0	8	0	*x*
98	Katy,* *Waller*	1938	13,500*x*	347,897		34	13				
99	Katy (North), *Waller*	1943	1,000*x*	249,059	194,061	15			11	0	
100	Kirby, *Liberty*	1943	400*x*	333,726	278,788	18	14	*x*	8	0	*x*
101	Kubela, *Wharton*	1936	650	1,732,101	200,874	21	0	*x*	5	13	0
102	La Belle, *Jefferson*	1937	900	1,175,767	345,682	12	4	0	7	1	*x*
103	Lakeview Gas Field,* *Wharton*	1936	60	*x*	*x*	3	0	*x*	*x*	*x*	*x*
104	Lake Creek, *Montgomery*	1941	1,000	305,594	44,290	18	6	*x*	2	1	*x*
105	Lane City, *Wharton*	1944	40	*x*	*x*	1	1	0	1	0	0
106	League City, *Galveston*	1938	740	4,213,678	1,116,547	37	0	*x*	27	5	*x*
107	Lissie, *Wharton*	1940	500	6,657		2	1	*x*	*x*	0	1
108	Livingston, Cockfield, *Polk*	1930	1,800*x*	8,234,223	472,110	115*x*	16	*x*	3	65	*x*
109	Livingston, *Sparta*	1942	Incl. above	72,578	38,122	Incl. above			4	0	*x*
110	Livingston, *Wilcox*	1942	Incl. above	146,100	119,155	Incl. above			7	1	*x*
111	Lochridge, *Brazoria*	1937	1,900	5,241,591	693,622	49			35	8	*x*
112	Lost Lake, *Chambers*	1929	(110) 40	1,038,618	1,183	13	0	*x*	0	1	*x*

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
55	x	x	0	22–28	x	Miocene, Mio	S	Por	1,600	12	DS	Frio	9,762
56	x	x	0			Frio, Olig	S	Por	4,465	20	DS		
57	x	x	0	37	x	Frio, Olig	S	Por	7,800	20	D	Frio	9,199
58	x	x	0	x	x	Frio, Olig	S	Por	7,525	x	DF	Frio	9,227
59	x	x	0	22	0.04	Frio, Olig	S	Por	4,050	15	D	Yegua	8,515
60	x	x	0	35	x	Frio, Olig	S	Por	6,150			Vicksburg	7,715
61	x	x	0	55	x	Cook Mt.	S	Por	8,070	10	x	Cook Mountain	8,461
62	x	x	0	21–41	0.02	Mio and Olig	S	Por	2,275	x	DS	Cook Mountain	10,505
63					0.04	Yegua and Cook Mt., Eoc	S	Por	7,341	20	DS		
64	x	x	0	37–51	x	Yegua, Eoc	S	Por	7,662	25	DF	Cook Mountain	9,038
65	3,000	x	0	39	x	Yegua, Eoc	S	Por	6,505	20	AF	Cook Mountain	9,740
66	540	x	0	26–38	x	Mio and Frio, Mio, Olig	S	Por	3,250	20–250	DS	Vicksburg	10,595
67	x	x	0	32	0.07	Frio, Olig	S	Por	8,214	60	DF	Frio	9,209
68	x	x	0	32	x	Frio, Olig	S	Por	8,962	5	D	Frio	9,952
69	x	x	0	39	x	Cockfield, Eoc	S	Por	5,790	4	x	Wilcox	11,794
70	x	x	0	39	x	Wilcox, Eoc	S	Por	8,180	15	D	Wilcox	8,500
71	x	x	0	55	x	Wilcox, Eoc			8,177			Wilcox	10,774
72	950	x	0	30	0.07	Frio, Olig	S	30	5,488	150	D	Vicksburg	8,450
73	x	x	0	44	x	Frio and Yegua, Olig, Eoc	S	Por	4,021	15–30	D	Wilcox	10,536
74	1,250	x	0	37	x	Frio, Olig	S	Por	8,300	15	D	Frio	9,463
75	x	x	0	51	x	Wilcox	S	Por	9,203	30x	x	Wilcox	10,516
76	x	x	0	32	x	Cockfield, Eoc	S	Por	4,030	5	D	Wilcox	9,966
77	x	x	0	20–36	0.08	Plio, Mio, Olig	S	Por	1,000	10	D	Vicksburg	6,975
78	1,300	x	0	22–52	x	Miocene	S	22–25	2,712	10	DS	Oligocene	9,636
79	x	x	0	x	x	Cap rock and Miocene	S Cav	Por	862	x	DS	Oligocene	4,586
80	8,500	x	0	47	x	Frio, Olig	S	Por	9,737	22	D	Frio	13,253
81	800	x	0	37	x	Frio, Olig	S	Por	8,182	10	D	Frio	10,497
82	x	x	0	40	0.07	Cockfield, Eoc	S	Por	6,952	2	x	Cockfield	7,018
83	424	x	0	18–32	x	Mio and Frio, Mio, Olig	S	20	2,407	29	DS	Vicksburg	7,891
84	900	x	0	37–56	0.07	Yegua, Eoc	S	30	7,547	10	D	Yegua	8,110
85	2,740	x	0	30–33	x	Frio, Olig	S	30	5,157	200	D	Vicksburg	8,793
86	200	x	0	x	x	Miocene	S	Por	5,150	10	DS	Oligocene	6,905
87	x	x	0	31	x	Miocene	S	Por	1,500	40	DS	Oligocene	7,179
88	x	x	0	25	x	Frio, Olig	S	Por	5,220	10	D	Frio	7,004
89	800	x	0	29–31	x	Miocene	S	Por	5,134	12	D	Frio	12,588
90	x	x	0	22	x	Cap rock and Olig	S Cav	Por	1,800	30	DS	Yegua	7,754
91	x	x	0	21	x	Miocene	S	Por	600	23	DS	Miocene	4,126
92	x	x	0	17–39	0.06	Mio, Frio, Yegua, and Cook Mt., Mio, Olig, Eoc	S	Por	400	63	DS	Cook Mountain	9,669
93	x	x	0	17–45	x	Cap, Mio, Frio and Yegua, Mio, Olig, Eoc	S	Por	700	4–200	DS	x	8,686
94	x	x	0	Gas		Miocene	S	Por	3,026	25	x	Yegua	8,501
95	x	x	0		x	Frio, Olig	S	Por	8,082	20	DF	Frio	9,994
96	1,425			40–47	x	Wilcox	S	Por	7,600	30	D	Wilcox	9,014
97	x	x	0	42–58	x	Yegua, Eoc	S	Por	6,500 6,900	10	D	Yegua	7,617
98			0			Yegua, Eoc	S	27	6,400	100	D	Wilcox	11,078
99			0			Yegua, Eoc	S	27	6,620	10	D	Wilcox	11,078
100	x	x	0	x	x	Yegua, Eoc	S	Por	8,400	30	DS	Cook Mountain	9,518
101	x	x	0	x	x	Frio, Olig	S	Por	4,596	x	D	Frio	6,260
102	x	x	0	37	0.06	Marginulina, Olig	S	30	8,260	11	D	Frio	10,147
103	x	x	0	24	x	Miocene	S	Por	3,185	15	x	Cockfield	7,607
104	x	x	0	61	0.04	Wilcox, Eoc	S	Por	9,200	50	D	Wilcox	13,330
105	x	x	0	26	x	Frio, Olig	S	Por	5,345	10	x	Frio	6,515
106	1,100 2,100	x	0	40	x	Frio, Olig	S	30	8,695	20	D	Vicksburg(?)	11,402
107	x	x	0	58	x	Yegua, Eoc	S	Por	6,728	6	x	Wilcox	10,116
108	700	x	0	40	0.05	Cockfield, Eoc	S	Por	3,285	20	D	Midway(?)	11,023
109	x	x	0	x	0.05	Cook Mt., Eoc	S	Por	6,300	x	D	Midway(?)	11,023
110	x	x	0	x	x	Wilcox, Eoc	S	Por	7,036	x	D	Midway(?)	11,023
111	2,100	x	0	26	0.01	Frio, Olig	S	20	6,309	20	DF	Vicksburg	9,684
112	x	x	0	22	x	Frio, Olig	S	Por	2,679	33	DS	Frio	7,471

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
113	Louise, *Wharton*	1933	1,600	4,610,288	350,496	52	0	*x*	3	29	*x*
114	Lovells Lake, *Jefferson*	1938	3,100	8,225,831	1,896,114	111	10	0	107	4	*x*
115	Lucky, *Matagorda*	1941	540	218,281	96,899	4	0	0	3	0	*x*
116	Magnet-Withers, *Wharton*	1936	9,000	18,590,840	3,142,197	256		0	203	53	*x*
117	Magnolia, *Montgomery*	1941	Abd.	1,682	0	1	0	0	0	0	*x*
118	Manvel, *Brazoria*	1931	1,800	28,950,122	3,041,254	195	0	*x*	90	71	*x*
119	Markham, *Matagorda*	1908	270	9,305,581	360,619	165*x*	2	*x*	14	25	2
120	Martha, *Liberty*	1939	500	812,374	161,311	12	0	0	3	9	0
121	Mayes, *Chambers*	1944	40	*x*	*x*	1	1	0	1	0	0
122	Menefee Gas Field,* *Wharton*	1943		0	0	1	0	0	0	0	1
123	Mercy, *San Jacinto*	1942	2,500*x*	2,166,289	1,100,931	38	0	0	36	2	*x*
124	Millican Gas,* *Brazos*	1942	0	0	0	1	1	0	0	0	1
125	Moore's, *Ft. Bend*	1926	300	4,219,714	56,795	36	1	*x*	1	9	*x*
126	Moss Bluff, *Liberty*	1930	Abd.	179,000	0	5	0	0	0	0	0
127	Mykawa, *Harris*	1930	350	4,871,098	105,142	45	1	*x*	1	29	*x*
128	Nada, *Colorado*	1944	640*x*	*x*	*x*	3	3	0	2	0	1
129	Nash, *Ft. Bend*	1926	Abd.	1,664,811	0	26	0	*x*	0	0	0
130	Needville, *Ft. Bend*	1942	380	98,678	34,899	13	8	*x*	5	1	4*x*
131	Nome, *Jefferson*	1936	750	4,056,218	545,728	44	1	*x*	4	29	1*x*
132	No. Bay City, *Matagorda*	1942	400	558,783	381,775	15	10	0	15	1	*x*
133	No. Beach Creek, *Hardin*	1944	40	*x*	*x*	1	1	0	1	0	0
134	No. Dayton, *Liberty*	1905	100*x*	2,374,761	1,790	64	2	*x*	0	2	*x*
135	No. Houston, *Harris*	1938	1,000	389,966	49,165	7	1	*x*	4	0	*x*
136	No. Louise, *Wharton*	1943	100*x*	*x*	*x*	2	1	*x*	*x*	*x*	*x*
137	No. Lovells Lake, *Jefferson*	1944	40	*x*	*x*	1	1	0	1	0	0
138	No. Markham, *Matagorda*	1938		44,204	0		*x*	*x*	1	0	*x*
139	No. Markham, *Carlson*	1941	1,350	291,515	208,806	39	*x*	*x*	4	0	*x*
140	No. Markham, *Cornelius*			351,483	1,458,702		*x*	*x*	34	0	*x*
141	No. Winnie, *Chambers*	1944	160	*x*	*x*	4	4	0	3	0	1
142	No. Withers, *Wharton*	1936	5,500	8,171,896	3,566,416	147	26	*x*	128	7	*x*
143	Old Ocean, *Brazoria*	1934	10,700	28,909,837	5,516,020	128	10	*x*	120	1	*x*
144	Orange, Cow Bayou, *Orange*	1913	400	33,270,399	98,112	328	0	*x*	0	35	*x*
145	Oyster Bayou, *Chambers*	1941	1,400	3,665,716	2,268,672	20	0	*x*	20	0	*x*
146	Palacios, *Matagorda*	1937	(300) 40	162,372	3,174	5	0	*x*	1	0	0
147	Pickett Ridge, *Wharton*	1935	1,200	4,412,038	525,447	51		1*x*	13	32	*x*
148	Pierce Junction, *Harris*	1921	350	36,618,431	470,909	201	1	1*x*	10	53	*x*
149	Pinehurst, *Montgomery*	1943	40	77,161	45,146	1	0	0	1	0	*x*
150	Pledger, *Brazoria*	1932	Abd.	17,000	0	13	0	*x*	0	0	*x*
151	Port Neches, *Orange*	1929	300	5,862,461	191,699	21	6	2*x*	7	11	0
152	Racoon Bend, Hockleyensis, *Austin-Waller*	1927	1,600	19,263,993	469,745	250	0	*x*	0	72	*x*
153	Racoon Bend, Cockfield	1934		12,515,668	3,230,478		0	*x*	42	41	*x*
154	Ramer's Island, *Tyler*	1942?	80*x*	80,478	80,478	2	0	0	2	0	*x*
155	Ramsey, *Colorado*	1943	100	1,219		1	0	*x*	*x*	*x*	*x*
156	Red Fish Reef, *Chambers*	1940	1,060	2,261,339	708,344	20	1	*x*	14	0	*x*
157	Rockland, *Jasper*	1928	40*x*	43,704	*x*	11	1	*x*	*x*	*x*	*x*
158	Rosenberg, *Ft. Bend*	1939	T/Abd.	24,271	0	2	0	0	0	0	0
159	Rosslyn, *Harris*	1938	40*x*	51,533	1,409	1	0	0	1	0	0
160	Rowan, *Brazoria*	1940	460	973,290	338,007	9	1	0	8	0	0
161	Sabine Pass, *Jefferson*	1941	Abd.	19,218	0	2	0	0	0	0	0
162	Sandy Point, *Brazoria*	1937	80	375,232	30,216	11	0	*x*	0	3	0
163	Saratoga, *Hardin*	1901	500	30,395,321	187,825	779	0	*x*	0	211	*x*
164	Satsuma, *Harris*	1936	600	987,264	160,514	19	1	*x*	7	3	*x*
165	Seabreeze, *Chambers*	1936	700	1,633,034	510,196	23	8	*x*	12	0	*x*
166	Sealy, *Austin*	1942	40	*x*	*x*	1	0	*x*	*x*	*x*	*x*
167	Segno, Deep, *Polk*	1938	2,100	6,040,003	989,021	84	3	*x*	39	25	*x*

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In. — Initial	Reservoir Pressure — Avg./End 1944	Secondary Recovery[h]	Character of Oil[i] — Gravity A.P.I. at 60°F.	Character of Oil — Sulphur, Per Cent	Producing Formation — Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944 — Name	Depth of Hole, Ft.
113	1,300–1,850	x	0	26–38	x	Frio, Olig	S	Por	5,135	15	D	Vicksburg	8,271
114	1,850	x	0	26	0.05	Frio, Olig	S	30	7,113	22	D	Frio	8,458
115	x	x	0	39	x	Frio, Olig	S	Por	8,833	10	D	Frio	10,500
116	2,350	x	0	26	x	Frio, Olig	S	Por	5,490	20	AF	Vicksburg	9,200
117	x	x	0	57	x	Wilcox, Eoc	S	Por	8,448	10	D	Wilcox	10,008
118	x	x	0	26	x	Mio, Frio, Mio, Olig	S	22–28	3,990	25	D	Vicksburg	7,957
119	x	x	0	25–40	x	Cap rock, Mio	{S Cav	}Por	936	20	DS	Vicksburg	8,581
120	3,509	x	0	41	x	Yegua, Eoc	S	30	8,100	5	D	Yegua	9,109
121	x	x	0	40	x	Frio, Olig	S	Por	8,166	20	DF	Frio	9,994
122	x	x	0	Gas		Frio, Olig	S	Por	4,540	10	D	Frio	4,600
123	x	x	0	38	0.04	Wilcox	S	Por	8,250	20	D	Wilcox	14,004
124	x	x	0	Gas		Wilcox	S	Por	3,342	6	DS	Cretaceous(?)	16,400 Still Drlg.
125	375	x	0	22–51	x	Mio, Frio, Yegua, Mio, Olig, Eoc	S	Por	1,265	25	DS	Cook Mountain	10,104
126	x	x	0	x	x	Cap rock, Olig	S{	Por Cav	} 800	33	DS	Vicksburg	7,375
127	x	x	0	27	x	Mio, Frio, Mio, Olig	S	Por	4,100	30	DF	Yegua	8,012
128	x	x	0	52	x	Yegua	S	Por	6,512	x	x	Yegua	7,087
129	x	x	0	23	x	Mio, Frio, Mio, Olig	S	Por	3,700	60	DS	Vicksburg	7,965
130	x	x	0		x	Frio, Olig	S	Por	5,176		D	Yegua	11,132
131	2,550	x	0	27	0.25	Marginulina, Olig	S	Por	4,775	12	DF	Vicksburg	9,045
132	x	x	0	35	x	Frio, Olig	S	Por	7,864	10	D	Vicksburg?	9,500
133	x	x'	0	35	x	Cockfield, Yegua	S		6,230		x	Wilcox	10,218
134	x	x	0	22–33	x	Cap rock and Miocene	S-L	{Por {Cav	} 400	x	DS	Vicksburg	5,700
135	x	x	0	x	x	Yegua, Eoc	S	Por	6,795	10	D	Yegua	7,940
136	x	x	0	x	x	Frio, Olig	S	Por	4,088	5	x	Vicksburg	6,007
137	x	x	0	29	x	Frio	S		7,176		D	Frio	9,963
138						Frio, Olig						Frio	9,010
139	3,450	x	0	36	x	Frio, Olig	S	Por	7,702	20	D	Frio	9,010
140												Frio	9,010
141	x	x	0	38	x	Frio, Olig	S	Por	8,757		DF	Frio	11,696
142	0	x	0	26	x	Frio, Olig	S	Por	5,490	20	AF	Vicksburg	9,200
143	4,700	x	0	52–68	x	Frio, Olig	S	27	8,636	200	D	Oligocene	14,378
144	x	x	0	20–42	x	Mio and Frio, Mio, Olig	S	Por	2,500	30	DS	Frio	7,550
145	x	x	0	36	x	Frio, Olig	S	Por	8,250	20	D	Frio	8,835
146	x	x	0	54	x	Frio, Olig	S	Por	7,830	15	D	Frio	11,337
147	2,053	x	0	26	x	Frio, Olig	S	33	4,596	15	A	Jackson	8,888
148	x	x	0	21–41	x	Mio, Frio, Vicks, Mio, Olig	S	Por	3,142	45	DS	Jackson	7,165
149	x	x	0		x	Wilcox, Eoc	S	Por	8,760	22	x	Wilcox	11,921
150	2,450	x	0	56	x	Frio, Olig	S	Por	6,580	x	D	Oligocene	9,096
151	x	x	0	25	0.06	Mio, Frio, Mio, Olig	S	Por	3,150	40	DS	Vicksburg	7,667
152	275	x	0	26	x	Hockleyensis, Eoc	S	Por	3,149	30	D	Wilcox }	9,515
153	1,800	x	0	33	x	Cockfield, Eoc	S	Por			D	Wilcox }	
154	x	x	0	45	x	Yegua, Eoc	S	Por	5,397	10	x	Wilcox	8,454
155	x	x	0	x	x	Wilcox, Eoc	S	Por	8,320	20	x	Wilcox	10,505
156	x	x	0	35–57	x	Frio, Olig	S	Por	8,796	15	x	Frio	11,008
157	x	x	0	21–35	x	Yegua, Eoc	S	Por	1,275	6	F	Cretaceous	10,363
158	x	x	0	55	x	Yegua, Eoc	S	Por	7,713	10	D	Cook Mountain	8,530
159	1,800	x	0	39	x	Yegua, Eoc	S	Por	6,947	10	x	Yegua	7,495
160	x	x	0	40–53	x	Frio, Olig	S	Por	8,538	18	DF	Frio	10,010
161	x	x	0	27	x	Miocene	S	Por	4,053	7	x	Miocene	7,097
162	2,680	x	0	46	x	Marginulina, Olig	S	30	6,480	3	D	Vicksburg	8,943
163	x	x	0	17–21	x	Cap rock, Mio, Olig	{L S	Cav Por	} 500	17	DS	Cook Mountain	7,461
164	3,100	x	0	42–45	x	Yegua, Eoc	S	Por	6,803	15	AF	Cook Mountain	8,050
165	3,900	x	0	40	x	Frio, Olig	S	Por	8,105	40	D	Frio	9,929
166	x	x	0	49	x	Wilcox, Eoc	S	Por	8,724	51	x	Wilcox	11,507
167	950	x	0	37	0.05	Wilcox, Eoc	S	17.5	8,190	30	D	Wilcox	11,734

oil. This discovery has possibilities of considerable importance, since it is associated with the large Jackson's Pasture structure.

Undesignated, Chambers County.—Wynn Crosby Drilling Co. et al. completed their No. 1 Mays-White on July 10, 1944, as a gas-condensate well in a Frio sand, through perforations at 8828 to 8836 ft. This discovery is not considered important. No other development was attempted during the year.

Nada Field, Colorado County.—Ohio Oil Co. completed the No. 1 C. W. McDermott Jan. 30, 1944, for 98 bbl. of 52.2° gravity condensate, and approximately 10 million cubic feet of gas from a Yegua sand at 6512 to 6520 ft. through ½-in. choke. Gas-condensate ratio was 100,510 to 1. Two other gas-condensate wells were completed during the year.

Columbus, Colorado County.—Cities Service Oil Co. et al, dually completed No. 1 C. K. Gay March 24, 1944, in Wilcox sands. It flowed 35 bbl. of 45.8° gravity condensate from perforations at 7667 to 7670 ft. through ⅛-in. choke; tubing

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
168	Segno, Shallow	1936	500	3,484,605	394,442	38	0	0	24	14	*x*
169	Shepherd, *San Jacinto*	1940	40	36,404	*x*	1	0	*x*	0	0	0
170	Shephards Mott, *Matagorda*	1936	Abd.	1,000	0	2	0	0	0	0	0
171	Sheridan, *Colorado*	1940	1,550	300,902	48,051	12	6	0	5	0	1*x*
172	Silsbee, *Hardin*	1936	1,000	4,660,831	679,407	51	0	*x*	19	20	*x*
173	Smith Point, *Chambers*	1944	200*x*	77,612	77,612	5	5	*x*	4	0	1
174	Sour Lake, *Hardin*	1902	960	81,384,748	536,062	815	0	*x*	14	120	*x*
175	South China, *Jefferson*	1939	250	922,140	250,846	16	0	*x*	9	4	*x*
176	South Cotton Lake, *Chambers*	1937	1,000	3,558,074	342,988	54	0	*x*	10	20	*x*
177	South Houston, *Harris*	1935	620	10,852,335	1,838,026	91	0	*x*	64	25	*x*
178	South Liberty, *Liberty*	1925	250	16,285,778	111,820	318	1	*x*	2	36	*x*
179	Spanish Camp, *Wharton*	1936				12	0		Gas		*x*
180	Spindletop, *Jefferson*	1901	500*x*	127,733,748	341,334	1,385	0	*x*	4	117	*x*
181	Splendora, *Montgomery*	1934	Abd.	1,000		1	0	0	0	0	0
182	Spring, *Harris*	1944	40	*x*	*x*	1	1	0	1	0	0
183	Spurger, *Tyler*	1940	*x*	89,025	36,180	1	0	0	1	0	0
184	Stowell, *Jefferson*	1941	3,200	6,584,730	5,490,209	80	32	0	76	4	3*x*
185	Stratton Ridge, *Brazoria*	1922	Abd.	12,000	0	5	0	0	0	0	0
186	Sublime, *Colorado*	1944	40	*x*	*x*	1	1	0	1	0	0
187	Sugarland, *Ft. Bend*	1928	1,200	36,134,875	3,091,045	71	0	*x*	31	17	*x*
188	Sugar Valley, *Matagorda*	1943	100	*x*	*x*	2	1	*x*		Shut in	
189	Thompson, *Ft. Bend*	1931	6,500	72,300,998	13,548,907	374	1	*x*	299	42	*x*
190	Tomball, *Harris*	1933	8,900	29,920,143	3,740,630	543	6	*x*	257	190	*x*
191	Turtle Bay, *Chambers*	1935	875	3,474,946	473,462	39	0	*x*	26	10	*x*
192	Turtle Bay, East, *Chambers*	1943	250	82,432	62,222	4	2		4	0	*x*
193	Village Mills Field, *Hardin*	1944	40*x*	*x*	*x*	1	1	0	1	0	0
194	West Aldine, *Harris*	1942	40*x*	7,380	*x*	1	0	*x*	*x*	*x*	*x*
195	West Beaumont, *Jefferson*	1936	650	5,978,828	630,865	60	0	*x*	23	30	*x*
196	West Columbia, *Brazoria*	1902	720	95,922,656	2,583,971	383	2	*x*	91	59	0
197	West Conroe, *Montgomery*	1941	40	31,711	10,012	1	0	0	1	0	0
198	West Garwood, *Colorado*	1941	200*x*	132,085	20,348	6	1	*x*	3	0	*x*
199	West Orange, *Orange*	1937	250	3,743,258	333,524	48	0	*x*	8	29	*x*
200	West Port Neches, *Orange*	1939	400	1,633,784	453,954	28*x*	0	*x*	14	13	*x*
201	West Silsbee, *Hardin*	1941	80*x*	112,430	29,296	2	0	0	0	2	*x*
202	Willow Slough, *Chambers*	1938	850	926,865	103,534	8	0	*x*	5	0	*x*
203	Wilson Creek, *Matagorda*	1937	80*x*	214,264		2	0	*x*	*x*	*x*	*x*
204	Winnie, *Jefferson*	1943		940,294	22,226	1	0	0	1	0	*x*
205					178,522,639						

pressure 1800 lb.; gas-condensate ratio, 15,700:1. From perforations at 7302 to 7314 ft., it flowed 70 bbl. of 55° gravity condensate through ¼-in. choke; casing pressure, 2100 lb.; gas-condensate ratio, 33,800 to 1. The discovery well was bottomed at 8037 ft. in Wilcox. There was no further development during 1944.

Frelsburg, Colorado County.—Sinclair-Prairie Oil Company's No. 1 A. J. Thompson was dually completed July 16, 1944, in Wilcox sands at: (1) 8177 to 8182 ft. for 73 bbl. of 54.8° gravity condensate through ¼-in. choke, with a casing pressure of 2090 lb. and a gas-condensate ratio of 41,781 to 1; and (2) 9288 to 9294 ft. for 59 bbl. of 59° gravity condensate, tubing pressure 700 lb. and gas-condensate ratio of 12,458 to 1. Total depth was 10,220 ft. No other wells were drilled during 1944.

Glasscock, Colorado County.—Sinclair-Prairie Oil Co. completed its No. 2 C. G. Glasscock Dec. 9, 1944, in the Wilcox section, through perforations at 9203 to 9208, 9216 to 9221, 9233 to 9238, and 9274 to 9280 ft. Initial production was

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
168	1,450	x	0	36–44		Cockfield, Eoc	S	Por	5,150	10	D	Wilcox	11,734
169	x	x	0	56	x	Wilcox	S	Por	8,215	x	x	Wilcox	8,590
170	x	x	0	x	x	Mio and Frio, Mio, Olig	S	Por	3,843	x	D	Frio	9,210
171	x	x	0	34–57	x	Wilcox, Eoc	S	Por	8,133	30	D	Wilcox	11,497
172	574	x	0	36–43	x	Cockfield, Eoc	S	Por	6,845	20	D	Cook Mountain	7,778
173	x	x	0			Frio, Olig						Frio	10,004
174	x	x	0	16–31	0.11	Yegua, Mio, Olig, Eoc	S	Por	500	100	DS	Yegua	7,914
175	x	x	0	37–52	x	Frio, Olig	S	Por	7,491	30	D	Frio	8,785
176	1,050	x	0	30–42	x	Marginulina, Frio, Olig	S	Por	6,409	x	DF	Frio	7,007
177	2,085	x	0	20–25	x	Mio and Frio, Mio, Olig	S	30	3,845	75	DS	Cockfield	9,474
178	x	x	0	21–47	0.06	Mio, Olig, Eoc	S	Por	700	100	DS	Cook Mountain	10,066
179	1,300			Gas	x	Miocene	S	Por	2,910	30	D	Yegua	8,183
180	x	x	0	25	x	Cap rock, Mio, Olig	S	Por	800	69	D	Frio	7,382
181	2,000	x	0	69	x	Cockfield, Eoc	S	Por	5,828	12	D	Wilcox	11,023
182	x	x	0	38.3	x	Cockfield, Eoc	S	Por	6,244		D	Yegua	6,450
183	x	x	0	x	x	Cockfield, Eoc	S	Por	4,685	19	D	Wilcox	7,759
184	x	x	0	35	0.02	Frio, Olig	S	Por	7,500	50±	DF	Vicksburg	12,505
185	x	x	0	32	x	Miocene	S	Por	4,300	10	DS	Oligocene	9,267
186	x	x	x	48	x	Wilcox	S	Por	9,500	x	x	Wilcox	9,990
187	1,570	x	0	28–35	x	Frio, Olig	S	25	2,500	80	DS	Yegua	8,575
188	x	x	0	x	x	Frio, Olig	S	Por	9,754		D	Oligocene	11,854
189	x	x	0	25–43	0.06	Mio, Frio and Vicksburg, Mio, Olig	S	25	3,600 4,400 5,000 7,700	15–80	D	Yegua	11,832
190	2,490	x	0	37–41	0.04	Cockfield, Eoc	S	25	5,682	10	D	Wilcox	8,955
191	2,958	x	0	32	x	Marginulina, Frio, Olig	S	Por	6,550	8	D	Vicksburg	8,497
192	x	x	0	x	x	Marginulina, Olig	S	Por		7	D	Frio	6,863
193	x	x	0	69.4	x	Cockfield, Yegua	S	Por	5,794			Yegua	7,006
194	x	x	0	40	x	Yegua, Eoc	S	Por	7,190	3	x	Yegua	7,991
195	x	x	0	26–34	x	Mio and Olig	S	Por	4,560	15	D	Vicksburg	8,501
196	x	x	0	28	x	Mio and Frio	S	Por	354	100±	DS	Vicksburg	8,518
197	x	x	0	x	x	Yegua, Eoc	S	Por	4,719	6	x	Yegua	6,016
198	x	x	0	52	x	Yegua and Wilcox, Eoc	S	Por	6,104	15	D	Wilcox	10,012
199	x	x	0	25	x	Frio, Olig	S	Por	5,585	8	DS	Frio	7,550
200	1,850	x	0	38	x	Mio and Frio, Mio, Olig	S	Por	3,150	40	DS	Vicksburg	7,667
201	x	x	0	41	x	Cockfield, Eoc	S	Por	6,918	5	D	Cook Mountain	7,778
202	3,900	x	0	34–37	0.07	Frio, Olig	S	25	8,400	10	DF	Frio	9,044
203	x	x	0	51	x	Frio, Olig	S	Por	9,968	28	x	Frio	10,796
204	x	x	0		x	Frio, Olig	S	Por				Vicksburg	11,732
205													

84 bbl. of 51.5° gravity condensate and 1,500,000 cu. ft. of gas through ¼-in. choke; tubing pressure, 1650 lb.; gas-condensate ratio, 18,200 to 1. Total depth was 10,516 ft. One other well, a dry hole, was drilled prior to the completion of the discovery well.

Sublime Field, Colorado County.—Tide Water Associated Oil Co. completed its No. 1 D. L. Underwood on Dec. 6, 1944, in a Wilcox sand at 9500 to 9505 for 79 bbl. of 48° gravity oil through 5/32-in. choke; tubing pressure, 715 lb.; gas-oil ratio, 18,180 to 1. There was no other development during 1944.

Village Mills, Hardin County.—No. 1 Hardin County School Land Fee was completed Nov. 8, 1944, by Houston Oil Co. et al. in a Yegua sand at 5794 to 5808 ft., for 23 bbl. of 69.4° gravity condensate through 18/64-in. choke. Casing pressure was 2150 lb. and total depth, 7006 ft. No other wells were completed during 1944.

Beach Creek, Hardin County.—American Republic Corporation and Houston Oil Co. completed their No. 1 H. & T. C. Fee May 16, 1944, in a Cockfield-Yegua sand at 6234 to 6352 ft. It had an initial production of 273 bbl. of 36.7° gravity oil through a ¼-in. choke. Tubing pressure was 700 lb., gas-oil ratio, 1774 to 1. Total depth, 6650 ft. One other oil well was drilled during 1944. Additional development will be required to determine the importance of this discovery.

North Beach Creek, Hardin County.—American Republic and Houston Oil Company's No. 1 Olive Sternenberg was completed on Apr. 27, 1944, in a Cockfield-Yegua sand, for 111 bbl. of 34.8° gravity oil and 256 bbl. of salt water. Production is from perforations made at 6230 to 6232 ft. on ¼-in. choke. Tubing pressure was 170 to 210 lb.; gas-oil ratio, 816 to 1; total depth, 6542 ft. One other well, a dry hole, was drilled during the year.

TABLE 2.—*Summary of Drilling Operations in Upper Texas Gulf Coast*

Important Wildcats Drilled in 1944

	County	Location, Survey	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
1	Chambers	Sec. 109	8,626	Beaumont	Frio
2	Chambers	F. Valmore	9,519	Beaumont	Frio
3	Chambers	Wm. Bryan	9,994	Beaumont	Frio
4	Chambers	G. Long	9,265	Beaumont	Frio
5	Colorado	Johnson & Stafford	7,087	Lissie	Yegua
6	Colorado	J. Tumlinson	8,037	Lissie	Wilcox
7	Colorado	C. Fritsche	10,220	Lissie	Wilcox
8	Colorado	J. Collier	10,516	Lissie	Wilcox
9	Colorado	M. Muldoon	9,990	Lissie	Wilcox
10	Hardin	Hardin Co. Sch. Ld.	7,006		Yegua
11	Hardin	H. & T. C. R.R. Co. #195	6,542		Yegua
12	Hardin	H. & T. C. R.R. Co. #189	6,650		Yegua
13	Harris	Mary C. Bulrice	6,249		Yegua
14	Jefferson	S. Corzine	9,963	Beaumont	Frio
15	Lavaca	D. B. Oakes	9,002		Wilcox
16	Lavaca	J. Kerr	7,620		Wilcox
17	Matagorda	A. Rawls	10,010	Beaumont	Frio
18	Wharton	J. Bagnal	7,445	Beaumont	Frio
19	Wharton	S. Castleman	5,727	Beaumont	Frio
20	Wharton	E. T. R.R. Co. #49	6,160	Beaumont	Frio
21	Wharton	J. W. Moore	8,501		Yegua
22	Trinity	Henry Bond	10,506		Comanchean
23	Brazos	E. M. Millican	16,664		Cretaceous(?)
24	Chambers	F. Valmore	11,566	Beaumont	Frio
25	Jefferson	David Burell	9,905	Beaumont	Frio

Spring, Harris County.—Eltex Ltd. discovered the Spring field when No. 1 Bender Estate was completed in a Cockfield-Yegua sand at 6244 to 6247 ft., for an initial production of 140 bbl. of 38.3° gravity oil through ⅛-in. choke. Tubing pressure was 840 lb.; casing pressure, 1090 lb.; gas-oil ratio, 250 to 1. Two dry holes completed the development for 1944.

North Lovells Lake.—Humble Oil and Refining Co. completed the No. 1 "C" Jefferson Land Co. Nov. 11, 1945, in a Frio sand at 7176 to 7180 ft., for 86 bbl. of 28.9° gravity oil through ⅛-in. choke. Tubing pressure was 2095 lb.; casing pressure, 2750 lb. S/1; gas-oil ratio, 4440 to 1. Development is still in progress.

Ashwood Field, Matagorda County.—Skelly Oil Co. completed the No. 1 C. B. Granbury Nov. 15, 1944, in a Frio sand, for 42 bbl. of 51.7° gravity condensate through 3/16-in. choke. Tubing pressure was 2350 lb.; gas-condensate ratio, 47,372 to 1. The well was bottomed at 10,010, still in Frio. There was no other development during 1944.

Daboval Field, Wharton County.—Amerada Petroleum Co. completed its No. 1 Chas. Daboval Oct. 2, 1944, in a Frio sand, at 7025 to 7027 ft. for 80 bbl. of 46.7° gravity oil through ⅛-in. choke. Tubing pressure was 2150 lb.; gas-oil ratio, 6470 to 1; total depth, 7445 ft. One other oil well was completed during the year.

Lane City Field, Wharton County.—General Crude Oil Company's No. 2 Security Bank & Trust Co. was completed Nov. 24, 1944, in a Frio sand at 5345 to 5350 ft. for 124 bbl. of 26° gravity oil through ⅛-in. choke. Tubing pressure was 1090 lb.; gas-oil ratio, 1613 to 1. This discovery is associated with the large Magnet Withers structure. The General Crude's No. 1 Security Bank, abandoned as a dry hole, was also drilled during 1944.

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1944

	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. Per Sq. In.		Remarks
		Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		Casing	Tubing	
1	Standard Oil of Texas	250		⅛		1,100	Discovery Smith Point
2	Sun Oil Co.	154		⅛	1,225	2,280	Discovery N. Winnie
3	Humble	768		¼			Discovery Mayes
4	Wynn Crosby Drlg. Co.						Discovery Undesignated
5	Ohio Oil Co.	98	10	½		2,325	Discovery Nada
6	Cities Service Oil Co.	35 70	½ 2⅓	⅛ ¼	2,100	1,800 Dual	Discovery Columbus
7	Sinclair-Prairie	73 59		¼ ¼	2,090	700 Dual	Discovery Frelsburg
8	Sinclair-Prairie	84	1½	¼		1,650	Discovery Glasscock
9	Tide Water Assoc. Oil Co.	79	1½	5/32		715	Discovery Sublime
10	Houston Oil Co.	23		13/64	2,150		Discovery Village Mills
11	Am. Rep. & Ho. Oil Co.	111		¼	Sealed	210	Discovery N. Beach Creek
12	Am. Rep. & Ho. Oil Co.	273		¼	Sealed	700	Discovery Beach Creek
13	Eltex Ltd.	140		⅛	1,090	840	Discovery Spring
14	Humble O. & R. Co.	86		⅛	2,750S/1	2,075	Discovery N. Lovells Lake
15	Sterling O. & R. Co.	93	3¾	⅛	2,800	2,685	Discovery Hope
16	Moran Corp.	67		5/32	560	320	Discovery Word
17	Skelly Oil Co.	42	2	3/16	Sealed	2,350	Discovery Ashwood
18	Amerada Petr. Corp.	80	½	⅛	Sealed	2,150	Discovery Daboval
19	General Crude Oil Co.	124		⅛	Sealed	1,090	Discovery Lane City
20	Seaboard O. Co.	185		¼	925	920	Discovery El. Campo
21	Superior of Calif.	0	1½	¼	Sealed	1,080	Discovery Hungerford
22	Navarro Oil Co.	Still testing					
23	Phillips Petr. Co.	Still drilling					
24	McCarthy Inc.	48	3½	11/64	3,800	4,060	New Sand. N. Winnie
25	Sun Oil Co.	16		¼		200	East ext., Fanncett

El Campo Field, Wharton County.—Seaboard Oil Co. completed the No. 1 W. W. Duson Jan. 12, 1944, in a Frio sand, at 6150 to 6154 ft. for 185 bbl. of 34.6° gravity oil through ¼-in. choke. Tubing pressure was 920 lb.; casing pressure, 925 lb.; gas-oil ratio, 454 to 1. Two other oil wells were completed during 1944.

Hungerford Field, Wharton County.—Superior Oil Company of California completed its No. 1 W. J. Hudgins in a Miocene sand at 3026 to 3031 for 1,545,000 cu. ft. of dry gas daily through a 14-in. choke. Tubing pressure (shut in) was 1350 lb. The discovery well, completed on May 8, 1944, was bottomed at 8501 ft. in Yegua sand. No other wells were completed during 1944.

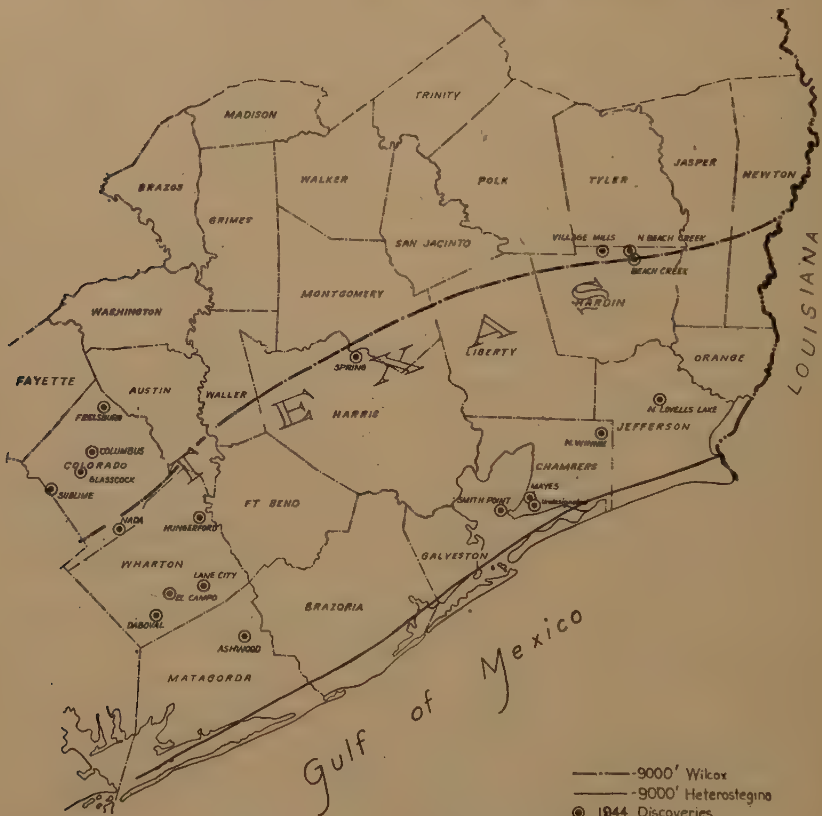

FIG. 1.—UPPER TEXAS GULF COAST, SHOWING DISCOVERIES OF 1944.
A map showing all Texas oil and gas districts appeared in *Trans.* A.I.M.E. (1944) 155, 469.

ACKNOWLEDGMENTS

The writers are indebted to Ruth E. Evans, Milton Scharck, and Leslie J. Franz for their valuable assistance in the preparation of this paper.

Oil and Gas Development and Production in North Texas for the Year 1944

By W. G. Sinclair*

The North Texas district incorporated in this paper corresponds with the Railroad Commission's District No. 9, and includes the counties of Archer, Baylor, Clay, Cooke, Foard, Hardeman, Jack, Knox, Montague, Wichita, Wilbarger, and Young.† Table 1, Oil and Gas Production in North Texas District, has been changed to conform with the nomenclature of pools designated by the Commission in order to facilitate compilation of the data, since most of the companies operating in the area are coming more and more to recognize one central authority in the matter of naming each new oil pool.

No effort is being made to discuss the structural characteristics of the region, since it is generally known by oil men that most of the oil and gas comes from Pennsylvanian, with some of less importance from the Mississippian and Ordovician.

Development during 1944

There were 1550 wells drilled during 1944, an increase of 450. Of this number, 677 were completed as oil wells, and 11 as gassers.

Production increased 1,505,025 bbl., making the year's total 43,172,005 bbl. of oil having an average gravity of 40°. Development generally, however, was somewhat disappointing. The 47 new pools, extensions, or new pay horizons in old fields, had a combined initial production of only 19,146 bbl. It is estimated that these wells added approximately 10,000,000 bbl. to the reserves.

The largest single addition to the reserves was in the Caddo conglomerate in the Hildreth pool, Montague County. During the year, 66 wells were completed as the result of three extensions, 1 to 1½ miles west, northwest and north of the field. Young, Archer, and Clay were the most active counties. Eleven new potential oil fields were developed in Young County, nine in Archer and nine in Clay.

Outlook for 1945

In spite of the fact that exploration as a whole was disappointing in 1944, prospects for increased development are bright for 1945.

At the close of last year, 21 geophysical crews were operating in the district, which, together with the Ohio Oil Company's No. 1 W. R. Ross, a wildcat Strawn discovery in King County, 1½ miles beyond the west boundary of district 9, stimulated a lease play extending over four counties. Two of them, viz., Foard and Knox, are in the area incorporated in this report.

Acknowledgments

The writer is indebted to Mr. C. W. Hanley, Zone Agent of the North Texas District, and Mr. William M. Lourcey, head of the Land, Leasing and Scouting Department for the Gulf Oil Corporation, both of Fort Worth, Texas, for permission to prepare this paper.

Manuscript received at the office of the Institute April 3, 1945.

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† A map showing all Texas oil and gas districts appeared in *Trans.* A.I.M.E. (1944) **155**, 469.

TABLE 1.—*Oil and Gas Production in North Texas District*

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Total Production, Bbl.[c]: To End of 1944	During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	1944: Completed	Abandoned
	Archer County:							
1	Burns-Ickert	1943	80	41,406	29,974	2	1	
2	Cooper	1942	280	130,801	65,085	7	1	
3	Daume	1944	40	1,910	1,910	1	1	
4	Garrett	1944	160	29,846	29,846	4	4	
5	Henry	1943	260	13,909	13,785	13	6	
6	Holliday	1944	160	48,233	41,987	4	4	
7	Hull-Silk-Sikes	1939	7,500	18,962,533	4,214,148	425	1	
8	Hull-Silk-Caddo	1940	800	413,488	47,619	16		
9	Kadane	1940	400	721,113	192,063	19		
10	Kadane-Shallow	1941	80	89,983	24,375	5		
11	Luke	1943	480	252,489	214,629	15	12	
12	Mankins	1939	500	822,108	146,330	14		
13	Ord	1943	120	16,958	15,084	3	2	
14	Scotland	1940	660	650,722	154,168	23		1
15	Scotland Mississippi Lime	1941	160	231,699	73,485	4		
16	Vogtsberger	1940	880	469,469	305,781	22	14	
17	All other fields	1911	42,800	130,766,505	2,492,993	3,324	80	223
18	Total Archer County		55,360	153,663,172	8,063,258	3,901	126	224
	Baylor County:							
19	Rendham	1940	600	273,986	65,103	14		1
20	Seymour	1939	1,600	1,760,871	451,903	35		3
21	All Other Fields	1924	600	5,205,664	109,592	121		4
22	Total Baylor County		2,800	7,240,521	626,598	170		8
	Clay County:							
23	Antelope	1939	900	1,866,848	573,909	54	1	
24	Antelope Mississippi Lime	1941	80	93,356	41,744	2		
25	Burns-Browning	1939	320	202,473	18,524	4		
26	Burns-Midway	1943	120	131,789	92,877	3	1	
27	Halsell	1939	500	689,528	161,249	13		
28	Hapgood	1940	120	264,492	62,936	3		
29	Joy Mississippi Lime	1940	700	735,996	357,528	13	2	
30	Kinder	1939	40	15,722	2,000	1		
31	New York City Mississippi Lime	1941	360	422,353	146,325	9		
32	New York City Strawn	1942	40	6,579	1,330	1		
33	Ross and Ross Dolomite	1939	960	514,861	88,748	28	3	
34	Ross-West	1944	40	2,429	2,429	1	1	
35	Scaling	1944	80	21,521	21,521	2	2	
36	Stephens	1943	80	64,589	33,393	2		
37	Watson	1942	600	156,448	58,012	10		
38	Wynn-Mississippi Lime	1943	200	193,059	184,221	5	4	
39	All other fields	1902	9,660	13,660,218	1,431,969	1,004	90	31
40	Total Clay County		14,800	19,042,261	3,278,715	1,155	104	40
	Cooke County:							
41	Bindel	1941	80	30,051	8,251	3		
42	Bindel Ellenburger	1941	120	115,988	75,009	3		
43	Dangle	1943	320	89,952	87,660	9	8	
44	Fleitman	1943	320	27,620	23,794	11	8	
45	Gatewood	1944	200	7,953	7,953	5	5	
46	Voth	1938	950	791,589	85,113	61		8
47	Walnut Bend	1938	3,000	7,570,149	1,669,362	131		
48	Walnut Bend Winger	1943	1,340	1,272,699	914,876	35	5	
49	Walnut Bend Montgomery	1944	240	49,848	49,484	5	5	
50	Wilson	1941	140	88,455	24,929	8		
51	Woodbine	1944	720	150,298	150,298	18	18	
52	All other fields	1924	4,000	23,564,686	1,166,059	1,017	23	14
53	Total Cooke County		11,430	33,759,288	4,262,788	1,306	72	22
	Foard County:							
54	Johnson	1933	380	1,793,282	43,846	10		
55	All other fields	1927	300	363,684	13,436	5		
56	Total Foard County		680	2,156,966	57,282	15		

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944 — Oil — Flowing	Wells Producing[g] Dec. 1944 — Oil — Artificial Lift	Character of Oil[i] — Gravity A.P.I. at 60°F.	Producing Formation — Name and Age[j]	Producing Formation — Character[k]	Producing Formation — Porosity, Per Cent[l]	Producing Formation — Depth to Top of Producing Zone, Ft.[m]	Producing Formation — Productive Thickness, Avg. Ft.,[n] Net	Producing Formation — Structure[o]	Deepest Zone Tested[p] to End of 1944 — Name	Deepest Zone Tested[p] to End of 1944 — Depth of Hole, Ft.
1		2	41	Bend, Pen	L	Por	4,468	39	A	Mississippian	5,165
2	3	4	43	Bend, Pen	L	Por	4,910	30	A	Ellenburger	5,028
3	1		43	Strawn, Pen	S	Por	4,074	14	A	Strawn	4,088
4		4	42	Strawn, Pen	S	Por	3,780	20	A	Ellenburger	5,685
5		13	36	Cisco, Pen	S	Por	900	5	A	Cisco	905
6	1	3	44	Strawn, Pen	S	Por	3,902	37	A	Strawn	4,389
7	78	347	44	Strawn, Pen	S, L,	Por	3,800	100	A	Ellenburger	5,880
				Strawn, Pen	Cg	Por	4,300	100	A	Ellenburger	5,880
8	3	13	44	Bend, Pen	L	Por	4,550	153	A	Ellenburger	5,880
9	11	8	42	Strawn, Pen	S	Por	4,337	10	A	Ellenburger	5,001
10		5	37	Cisco, Pen	S	Por	1,572	8	AM	Ellenburger	5,001
11	12	3	42	Bend, Pen	L	Por	4,881	10	A	Ellenburger	5,623
12	4	10	44	Bend, Pen	L	Por	4,660	30	A	Ellenburger	5,425
13		3	42	Bend, Pen	L	Por	5,130	62	A	Ellenburger	5,890
14	20	3	43	Bend, Pen	L	Por	5,030	100	A	Ellenburger	5,850
15	3	1	44	Bend, Pen	L	Por	5,254	174	A	Ellenburger	5,850
16	20	2	42	Strawn, Pen	S	Por	4,656	15	A	Ellenburger	5,335
17	11	3,313	39	Cisco, Canyon, Pen	S, L	Por	*x*	*x*	*x*	Granite	7,915
18	167	3,734									
19		14	38	Canyon, Pen	L	Por	3,025	4	M	Strawn	4,326
20		35	36	Canyon, Pen	L	Por	2,525	20	N	Ellenburger	5,598
21		121	38	Gunsite, Pen	S	Por	1,440	20	ML	Strawn	4,265
22		170									
23	7	47	40	Bend, Pen	L	Por	3,550	20	AM	Ellenburger	6,168
			40	Strawn, Pen	S	Por	3,150	38	AM	Ellenburger	6,168
24	2		41	Chappell, Mis	L	Por	5,670	90	*x*	Ellenburger	6,168
25		4	44	Strawn, Pen	S	Por	4,430	20	A	Ellenburger	6,168
26	2	1	45	Chappell, Mis	L	Por	6,010	40	A	Ellenburger	6,298
27		13	42	Canyon, Pen	L	Por	3,600	17	A	Ellenburger	6,048
			42	Strawn, Pen	S	Por	4,756	44	A	Ellenburger	6,048
28	2	1	47	Bend, Pen	Cg	Por	5,972	20	A	Ellenburger	6,538
29	7	6	45	Chappell, Mis	L	Por	5,894	73	A	Ellenburger	6,255
30		1	44	Strawn, Pen	S	Por	4,128	22	A	Ellenburger	5,527
31	9		47	Chappell, Mis	L	Por	6,180	120	A	Ellenburger	6,837
32		1	44	Strawn, Pen	S	Por	4,911	29	A	Ellenburger	6,837
33	6	22	46	Bend, Pen	S, L	Por	5,358	32	A	Ellenburger	6,145
			46	Ellenburger, Ord	D	Por	5,626	31	A	Ellenburger	6,145
34	1		42	Bend, Pen	L	Por	5,395	40	A	Ellenburger	5,680
35	2		41	Bend, Pen	L	Por	5,554	16	A	Ellenburger	6,160
36	1	1	48	Chappell, Mis	L	Por	6,011	28	A	Ellenburger	6,720
37	2	8	41	Strawn, Pen	S	Por	3,640	22	A	Ellenburger	6,051
			43	Bend, Pen	L	Por	5,452	30	A	Ellenburger	6,051
38	5		46	Chappell, Mis	L	Por	6,153	130	A	Ellenburger	6,814
39	19	986	42	Cisco, Canyon, Pen	S	Por	*x*	*x*	*x*	Ellenburger	6,837
40	65	1,090									
41		3	39	Strawn, Pen	S	Por	1,885	10	A	Ellenburger	3,784
42	1	2	36	Ellenburger, Ord	D	Por	3,242	9	A	Ellenburger	3,784
43	5	4	37	Ellenburger, Ord	D	Por	2,179	8	A	Granite	2,520
44		11	40	Strawn, Pen	S	Por	1,133	7	A	Ellenburger	1,703
45		5	35	Strawn, Pen	S	Por	1,578	7	A	Strawn	1,585
46		61	38	Ellenburger, Ord	L	Por	1,625	10	A	Ellenburger	1,793
47	1	130	36	U. Strawn, Pen	S	Por	4,108	7	N	Ellenburger	6,110
48	29	6	34	L, Strawn, Pen	S	Por	5,491	42	N	Ellenburger	6,110
49	2	3	47	Strawn, Pen	S	Por	5,112	19	*x*	Ellenburger	6,310
50		8	42	Strawn, Pen	S	Por	2,221	10	AM	Ellenburger	4,302
51	1	17	28	Strawn, Pen	S	Por	4,118	18	*x*	Ellenburger	4,867
				Strawn, Pen	S	Por	4,349	8		Ellenburger	
				Strawn, Pen	S	Por	4,512	10		Ellenburger	
52	1	1,017	40	*x*	S, L	Por	*x*	*x*	*x*	Ellenburger	8,331
53	40	1,266									
54	1	9	50	Canyon-Pen	L	Por	3,565	42	A	Pre-Cambrian	5,003
55		5	39	Cisco, Pen	S	Por	2,050	14	A	Strawn	2,064
56	1	14									

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Oil Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Completed to End of 1944	1944	
				To End of 1944	During 1944		Completed	Abandoned
	Hardeman County:							
57	Chillicothe	1944	40	747	747	1	1	
58	All other fields							
59	Total Hardeman County		40	747	747	1	1	
	Jack County:							
60	Birdwell	1939	80	34,557	5,807	2		
61	East Bryson	1938	3,280	4,632,168	574,524	153	1	
62	Ellis	1942	800	379,202	284,155	22	11	
63	Ellis-Strawn	1944	120	18,613	18,613	3	3	
64	Hoefle	1941	920	557,687	211,633	23	3	
65	McDonald	1938	460	146,827	124,299	12	9	
66	Meyers	1938	150	87,852	26,495	6		
67	Peek	1943	120	66,977	51,102	4	3	
68	Taubert-McKee	1942	40	7,724	1,125	1		
69	Webb	1941	40	4,473	957	1		
70	Weir	1943	240	36,926	30,483	6	4	
71	Wolfe	1943	40	26,471	13,571	2	1	
72	Worsham-Steed	1942	120	78,559	34,979	3	1	
73	All other fields	1907	5,860	18,382,789	652,248	562	12	43
74	Total Jack County		12,270	24,460,825	2,029,991	800	50	46
	Montague County:							
75	Benson	1941	100	71,059	9,307	4		
76	Bonita	1940	380	1,124,196	245,993	20		
77	Bowers	1939	1,210	1,411,449	339,443	39		
78	Chapman-McFarlin	1941	40	65,304	19,907	1		
79	Clingingsmith	1941	200	183,612	44,534	5		
80	Dodson	1940	560	688,454	424,028	26	13	
81	Forestburg	1942	240	259,545	47,772	6		
82	Hildreth	1942	3,240	1,394,646	1,214,273	70	66	
83	Hults and Owens	1940	80	98,256	2,743	2		
84	Hundley	1944	80	16,804	16,804	2	2	
85	Illinois Bend	1942	240	143,420	98,624	5	1	
86	Mueller	1942	80	85,274	26,659	3	2	
87	Mueller Caddo	1943	200	234,237	182,579	6	2	
88	Ringgold (Montague and Clay Counties)	1940	680	883,759	185,031	16	4	
89	Rogers and Rogers	1939	900	2,176,422	328,946	41	3	
90	Sanders	1942	160	229,984	65,352	4		
91	Stoneburg	1941	240	103,745	43,767	6	1	
92	Turner	1941	40	25,343	3,722	1		
93	All other fields	1918	5,000	37,513,629	1,320,025	970	28	24
94	Total Montague County		13,630	46,709,138	4,437,509	1,227	122	24
	Wichita County:							
95	Airport	1943	80	16,489	5,684	2	2	3
96	Davidson	1943	140	79,630	64,490	4	2	
97	K. M. A.	1931	30,400	59,154,751	7,255,867	1,614	3	6
98	K. M. A.-Ellenburger	1940	6,320	8,014,505	2,290,910	177	8	
99	West	1943	520	179,827	146,014	13	10	
100	All other fields	1911	54,700	334,095,646	3,607,474	5,382	89	357
101	Total Wichita County		92,160	401,540,848	13,370,439	7,192	114	366
	Wilbarger County:							
102	Consolidated	1939	700	1,719,477	191,456	43	1	
103	Electra Ellenburger	1941	80	36,887	9,376	2		
104	Fargo	1940	2,000	3,269,487	1,010,470	49		
105	Harrold	1941	400	294,854	84,249	14	1	
106	King	1939	80	82,079	4,494	8		

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944, Oil: Flowing	Wells Producing[g] Dec. 1944, Oil: Artificial Lift	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
57		1	44	x	L	Por	4,250	27	x	x	7,301
58											
59		1									
60	1	1	41	Marble Falls, Pen	L	Por	4,384	20	A	Bend-Mis	4,507
61	5	148	42	Strawn, Pen	S	Por	3,111	10	A	Ellenburger	5,435
62	22		43	Bend, Pen	L	Por	4,785	43	A	Ellenburger	5,901
63	1	2	42	Strawn, Pen	S	Por	3,629	8	A	Ellenburger	5,901
64	13	10	43 43	Strawn, Pen Bend, Pen	S L	Por Por	2,712 4,794	x 41	A	Ellenburger	6,177
65	6	6	33	Strawn, Pen	S	Por	3,518	20	x	Ellenburger	6,040
66		6	40	Strawn, Pen	S	Por	2,401	10	x	Ellenburger	6,215
67	4		40	Bend, Pen	L	Por	4,579	10	x	Bend	4,589
68		1	42	Ellenburger, Ord	D	Por	6,388	47	x	Ellenburger	6,501
69	1		42	Strawn, Pen	S	Por	2,892	16	x	Ellenburger	6,175
70	1	5	41	Strawn, Pen	S	Por	2,322	10	x	Ellenburger	6,011
71	1	1	40	Bend, Pen	L	Por	4,366	60	x	Ellenburger	5,631
72		3	41	Strawn, Pen	L	Por	4,696	20	x	Bend-Penn	5,252
73	15	548	38	x	x	x	x	x	x	Ellenburger	7,048
74	70	730									
75	1	3	44	Bend, Pen	Cg	Por	5,840	10	x	Ellenburger	6,213
76	6	14	40	Strawn, Pen Bend, Pen	S S	Por Por	5,234 5,442	10 14	A	Ellenburger	6,975
77	7	32	40	Canyon, Pen Strawn, Pen	L S	Por Por	2,020 2,880	10 15	A	Granite	4,300
78		1	44	Strawn, Pen	S	Por	4,826	36	x	Ellenburger	6,217
79		5	40	Bend, Pen	Cg	Por	5,962	69	N	Bend	6,250
80	23	3	44	Bend, Pen Bend, Pen	L, Cg L, Cg	Por Por	5,127 5,291	25 8	A	Ellenburger	6,368
81	2	4	40	Bend, Pen	L	Por	7,176	53	x	Ellenburger	8,696
82	70		40	Bend, Pen Simpson, Ord	Cg S	Por Por	6,050 7,170	150 56	x	Ellenburger	7,413
83	1	1	45	Bend, Pen	L	Por	6,002	48	x	Bend	6,303
84	2		42	Bend, Pen	Cg	Por	6,228	7	x	Ellenburger	8,018
85		5	30	Strawn, Pen	S	Por	3,463 3,860	10 12	x	Ellenburger	4,880
86	1	2	42	Simpson, Ord	S	Por	7,218	5	A	Ellenburger	7,270
87	4	2	40	Bend, Pen	L	Por	6,015	40	A	Ellenburger	7,270
88	8	8	48	Bend, Pen	Cg	Por	5,695	20	x	Ellenburger	6,092
89	10	31	43	Strawn, Pen Bend, Pen	S, L Cg, L	Por Por	4,645 5,224	9 11	A A	Ellenburger	6,988
90	2	2	36	Bend, Pen	Cg	Por	5,975	50	x	Ellenburger	6,860
91	1	5	44	Bend, Pen	Cg	Por	6,080	30	x	Simpson	7,224
92		1	41	Bend, Pen	Cg	Por	6,222	19	x	Ellenburger	7,501
93	2	968	x	x	x	x	x		x	Ellenburger	8,616
94	140	1,087									
95		2	44	Strawn, Pen	S	Por	4,415	50		Ellenburger	5,401
96	1	3	47	Ellenburger, Ord	D	Por	5,350	11		Ellenburger	5,364
97	750	864	42	Strawn, Pen	SL	Por	3,689	41	AC	Ellenburger	5,430
98	100	77	42	Ellenburger, Ord	DL	Por	4,330	30	AC	Ellenburger	5,430
99	11	2	40	Strawn, Pen	S	Por	4,228	30	x	Ellenburger	5,687
100	50	5,332	40	Cisco, Pen	S, L	Por	x	x	x	Ellenburger	6,109
101	912	6,280									
102	9	34	40	Strawn, Pen	LS	Por	3,750	20	x	Ellenburger	4,450
103		2	43	Ellenburger, Ord	D	Por	3,627	8	x	Ellenburger	3,635
104	1	48	42	Cisco, Pen Canyon, Pen Strawn, Pen	S L S	Por Por Por	3,278 4,028 4,430	20 18 15	A	Ellenburger	6,717
105		14	40	Cisco, Pen Canyon, Pen	S S	Por Por	2,095 3,160	10 12	A	Ellenburger	5,146
106	7	1	38	Cisco, Pen Canyon, Pen	S S	Por Por	1,220 1,900	10 12	A	Strawn	2,671

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
107	Main	1943	100	58,208	56,160	6	1	
108	O'Dell	1944	160	12,294	12,294	4	4	
109	Potts-Ellenburger	1942	80	36,960	3,956	2		
110	Rock-Crossing-Canyon	1940	680	947,898	217,791	32		
111	Rock-Crossing-Ellenburger	1941	300	348,457	112,291	7		
112	Rogers-McCrary	1943	100	41,769	24,191	5		
113	All other fields	1915	15,000	78,864,097	1,868,229	1,552	6	16
114	Total Wilbarger County		19,680	85,712,467	3,594,957	1,724	13	16
	Young County:							
115	Allar	1941	360	170,646	114,161	15	3	
116	Allar Caddo	1943	120	21,900	10,049	3		
117	Anzac-Graham	1939	160	125,990	25,439	4		
118	Blount	1940	40	14,980	1,518	1		
119	Briar Creek	1941	160	182,361	55,119	8		
120	Burns-Larimore	1941	160	91,241	19,089	4		
121	Burns Ragland Mississippi Lime	1941	240	183,067	56,389	6		
122	Burns Ragland Strawn	1944	80	19,864	19,864	2		
123	Daws	1942	40	12,990	4,098	1		
124	Edmonds	1943	80	27,944	24,652	2		
125	Fish Creek	1937	40	11,198	4,433	1		
126	Garvey	1941	80	72,010	37,542	2		
127	Holbert Caddo	1942	40	49,942	22,894	1		
128	James	1928	3,200	2,801,295	121,356	48		3
129	Kerlyn-Loving	1940	100	57,637	10,021	4		
130	Knight	1938	800	902,762	39,523	25		9
131	Knox	1931	1,040	963,318	69,808	26		
132	Knox North Caddo	1936	780	488,940	87,051	20		
133	Knox Mississippi Lime	1942	160	175,218	66,777	4		
134	Lupton-McLester	1931	1,040	967,650	164,714	44		
135	Murray	1942	280	202,917	108,458	4		
136	Murray Caddo	1943	40	42,831	29,287	1		
137	Padgitt Mississippi Lime	1942	280	244,049	120,517	7	3	
138	Sewell	1938	1,720	1,476,128	190,137	42	5	2
139	Taylor	1941	80	15,619	2,900	2		
140	Walsh	1943	80	34,609	33,024	2	1	
141	Williamson	1941	240	163,615	39,099	5	1	
142	All other fields	1917	20,000	73,375,510	1,971,802	2,180	60	147
143	Total Young County		31,440	82,896,281	3,449,721	2,464	75	161
144	Total North Texas District		254,290	857,182,514	43,172,005	19,955	677	907

TABLE I.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
107		6	38	Canyon, Pen	L	Por	2,786	10	*x*	Granite Wash	4,725
108	4		43	Canyon, Pen	L	Por	4,750	60	*x*	Strawn	4,956
109		2	42	Ellenburger, Ord	D	Por	4,506	48	*x*	Ellenburger	4,557
110	4	28	39	Canyon, Pen	L	Por	3,015	17	*x*	Ellenburger	3,883
111	3	4	39	Ellenburger, Ord	D	Por	3,804	11	*x*	Ellenburger	3,883
112		5	41	Cisco, Pen	S	Por	1,476	11	N	Cisco	1,489
113	6	1,546	40	Cisco, Canyon, Strawn	S, L	Por	*x*	*x*	*x*	Ellenburger	6,612
114	34	1,690									
115	11	4	38	Strawn, Pen	S	Por	2,706	15	A	Ellenburger	4,485
116	2	1	37	Bend, Pen	L	Por	3,550	20	A	Ellenburger	4,485
117		4	32	Bend, Pen	L	Por	4,432	47	*x*	Mississippi	4,750
118		1	40	Strawn, Pen	S	Por	3,051	10	*x*	Bend	4,683
119	1	7	41	Strawn, Pen Bend, Mis	S L	Por Por	2,800 4,834	10 19	A	Mississippi	4,859
120	2	2	45	Bend, Mis	L	Por	4,896	31	A	Mississippi	5,100
121	3	3	42	Bend, Mis	L	Por	4,853	28	A	Ellenburger	5,288
122		2	41	Strawn, Pen	S	Por	2,584	14	A	Ellenburger	5,288
123		1	38	Bend, Pen	L	Por	3,847	15	*x*	Ellenburger	4,920
124	2		40	Bend, Pen	L	Por	4,184	6	*x*	Ellenburger	4,768
125	1		42	Bend, Pen	L	Por	3,338	20	*x*	Bend	3,637
126		2	43	Bend, Pen	L	Por	4,280	22	*x*	Ellenburger	5,437
127		1	39	Bend, Pen	L	Por	3,857	7	*x*	Ellenburger	5,276
128	15	33	40	Bend, Pen Bend, Pen	L L	Por Por	3,867 4,275	20 18	A	Ellenburger	5,442
129		4	42	Strawn, Pen Bend, Pen	S L	Por Por	2,920 4,050	35 20	A	Ellenburger	5,292
130	3	22	40	Bend, Pen	L	Por	3,762	38	A	*x*	4,340
131	10	16	42	Strawn, Pen	S	Por	2,800	20	A	Mississippi	4,853
132	11	9	42	Bend, Pen	L	Por	4,048	17	A	Mississippi	4,853
133	3	1	43	Mississippi, Mis	L	Por	4,760	10	A	Mississippi	4,853
134	33	11	40	Bend, Pen	L	Por	3,750	50	A	Mississippi	4,850
135	3	1	43	Mississippi, Mis	L	Por	4,460	43	*x*	Ellenburger	4,839
136	1		40	Bend, Pen Bend, Pen	L L	Por Por	3,635 4,181	10 14	*x*	Ellenburger	4,839
137	7		44	Mississippi, Mis	L	Por	4,748	47	*x*	Ellenburger	5,001
138	25	17	44	Strawn, Pen Strawn, Pen Bend, Pen	S S L	Por Por Por	2,476 3,925 4,260	20 18 25	A	Ellenburger	4,636
139	1	1	44	Bend, Pen	L	Por	4,249	11	*x*	Ellenburger	5,377
140	2		43	Bend, Pen	L	Por	4,242	17	*x*	Ellenburger	4,858
141		5	45	Strawn, Pen Bend, Pen Mississippi, Mis	S L L	Por Por Por	2,940 3,960 4,974	20 18 32	A	Ellenburger	5,246
142	37	2,143	40	*x*	*x*		*x*	*x*	*x*	Ellenburger	5,456
143	173	2,291									
144	1,602	18,353									

TABLE 2.—*Summary of Drilling Operations in North Texas*

Important Wildcats Drilled in 1944

	County	Location	Total Depth, Ft.	Pay	Deepest Horizon Tested
1	Archer	J. W. Harris, lot 23	1,498	OS 1491–1498	Cisco
2	Archer, Garrett pool	J. Walker, A-676	5,685	OS 3780–3800	Ellenburger
3	Archer, Holliday pool	S. P. R. R., sec. 2, A-1233	4,375	OS 3902–3939	Strawn
4	Archer, Daume	S. P. R. R., sec. 1, A-422	4,088	OS 4074–4088	Strawn
5	Archer	A. T. N. C. L., sec. 109	5,724	LSO 4864–4874	Ellenburger
6	Clay	M. E. P. & P., sec. 12, A-339	6,672	Cg 5929–5959	Ellenburger
7	Clay	W. & H. Sub., lot 27, A-22	4,770	Sd 4745–4770	Strawn
8	Clay	H. Williams, lot 32, A-704	3,950	OS 3928–3943	Strawn
9	Clay	T. E. & L., sec. 3245	6,817	LSO 6490–6515	Ellenburger
10	Clay, Ross-Dolomite	W. E. Williams, A-703	6,145	D 5626–5657	Ellenburger
11	Clay, Ross-West	B. B. B. & C., sec. 7, A-49	5,680	LSO 5395–5435	Ellenburger
12	Clay	Webb Sub., lot 21, A-403	6,234	Cg 5855–5863	Mississippian
13	Clay	Belcher sub., lot 44	6,035	D 5842–5875	Ellenburger
14	Clay, Scaling	J. Gamble, 1, A-168	6,160	LSO 5554–5570	Ellenburger
15	Cooke, Gatewood	M. E. P. & P., A-766	1,585	OS 1578–1585	Strawn
16	Cooke, Woodbine	G. De Los Santos, A-894	4,867	OS 4349–4357	Ellenburger
17	Cooke, Walnut Bend Montgomery	R. Finney, A-389	5,137	OS 5112–5131	Ellenburger
18	Cooke	B. B. B. & C., A-150	2,983	Cg 2978–2983	Bend
19	Cooke	T. W. Ward, A-1089	5,727	LSO 5409–5463	Ellenburger
20	Cooke	J. Massingill, A-687	7,518	OS 6761–6777	?
21	Hardeman	H. & T. C., Blk. 10, sec. 49	7,301	L 4250–4277	?
22	Jack	H. C. S. L. Blk. 2, sec. 13	6,407	Cg 4381–4423	Ellenburger
23	Jack, Ellis-Strawn	J. W. Williams, lot 4, A-877	4,722	L 3629–37	Strawn
24	Jack, Ellis-Strawn	J. W. Williams, lot 6, A-877	3,666	OS 3606–3611	Strawn
25	Jack	J. W. Blankenship, A-1447	3,977	Sd 2300–2314	
26	Jack	J. M. Brown, A-59	4,803	OS 4740–4750	Bend
27	Jack	M. & W., A-435	5,512	LSO 5458–5512	Mississippian
28	Jack	M. & W., A-435	5,744	LSO 4906–4980	Ellenburger
29	Montague	T. R. Jackson, A-394	4,545	OS 2808–2818	Ellenburger
30	Montague, Hundley	D. Martindale, A-465	8,018	Cg 6228–6235	Ellenburger
31	Montague	E. T. R. R., sec. 38, A-1069	7,299	L 6715–6735	Ellenburger
32	Montague	S. H. Smith, A-662	6,332	Cg 6114–6158	Bend
33	Montague	W. E. Davis, A-210	6,230	Cg 6000–6024	Bend
34	Montague	J. Castleberry, A-131	6,323	Cg 5965–87	Bend
35	Montague	E. Wingate, A-836	6,330	LSO 6047–6077	Bend
36	Wichita	R. Evans, A-74	4,650	OS 4311–25	Strawn-Pen
37	Wichita	Wm. Mayer, lot 8, A-193	5,131	L 5070–5090	Bend-Pen
38	Wichita	Wm. Mayer, lot 8, A-193	5,350	L 4280–4305	Bend-Pen
39	Wichita	K. W. V. F. L., lot 15, Blk. 26	4,160	L 4114–4160	Ellenburger
40	Wilbarger O'Dell	H. & T. C., sec. 5, Blk. 5	4,841	L 4750–4810	Canyon-Pen
41	Wilbarger	H. & T. C., sec. 56, Blk. 4	1,287	OS 1280–87	Cisco-Pen
42	Young	T. E. & L., sec. 495	4,354	L 4354–4371	Bend-Pen
43	Young, Burns, Ragland, Strawn	T. E. & L., sec. 255	4,984	OS 2584–98	Strawn
44	Young	B. S. & F., sec. 2, A-2211	4,724	L 4456–4462	Ellenburger
45	Young	W. A. Nicholson, A-1697	5,910	L 5263–69	Ellenburger
46	Young	T. E. & L., sec. 1856	4,483	L 4463–83	Bend-Pen
47	Young	J. C. Vanhooser, A-1648	1,938	OS 1932–38	Cisco
50	Total				

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1944

	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. Per Sq. In.: Casing	Pressure, Lb. Per Sq. In.: Tubing	Remarks
1	D. H. Bolin	8			6 5/8 1485		New pay
2	Consolidated-Premier	112			6 5/8 5014		Perf c.s.g. 3780–3800
3	G. W. Cooper	132		13/64 on 2	6 5/8 3890	50	New pay
4	G. W. Cooper	660		1/2 on 2	6 5/8 4065	500	New pay
5	Phillips Petr. Co.	244		3/8 on 2	850	800	Ext. to Luke pool
6	Anderson-Prichard	384		5/8 on 2	850	40	New pay
7	Bridwell Oil Co.	386		1/4 on 2	275	220	New pay
8	L. T. Burns	337	600/1	1/4 on 2	500	250	Extension
9	Continental Oil Co.	167		none			New pool
10	Continental Oil Co.	274	1,009/1	1/2 on 2	450	20	New pay old pool
11	Fain & McGaha	822	750/1	1/2 on 2	1,060	300	Ext. to old pool
12	Lacy & Flannery	94					New pool
13	Phillips Petr. Co.	75					New pool
14	H. F. Wilcox O. & G. Co.	960	863/1	1/2 on 2	900	640	New pool
15	S. D. Johnson	157					New pool
16	Northern Ord. Inc.	110		13/64 on 2	150	25	New pool
17	Sinclair Prairie	1,212	776/1	open 2	450	80	New pool
18	Kadane-Griffith	845		1/2 on 2	90	60	New pool
19	The Texas Co.	331		1/2 on 2	725	200	New pool
20	The Texas Co.	139					New pool
21	Humble O. & R. Co.	19	414/1				New pool
22	Continental Oil Co.	408	400/1	1/2 on 2	400	140	New pool
23	Hanlon-Buchanan	511	1,377/1	1/4 on 2	720	530	New pay, old pool
24	Hanlon-Buchanan	633	675/1	open 2			Ext. new pay, old pool
25	C. F. Peffley		3,500,000				New pool
26	Rathke Oil Co.	5					New pool
27	Shell Oil Co.	1,968	1,014/1	2 open	750		New pool
28	Shell Oil Co.	240	695,000	2 open			New pay, old pool
29	Chapman & McFarlin	157					New pay, old pool
30	Continental Oil Co.	800	856/1	2 open	965	1,045	New pool
31	Continental Oil Co.	266	1,000/1	12/64 on 2	1,500	550	New pool
32	Nu-Enamel Oil Opr. Co.	1,008	700/1	3/8 on 2	500	500	Ext. to old pool
33	Nu-Enamel Oil Opr. Co.	1,104	695/1	1/2 on 2	350	400	Ext. to old pool
34	Nu-Enamel Oil Opr. Co.	448	500/1	3/8 on 2	600	250	Ext. to old pool
35	Sinclair Prairie	104					New pool
36	A. R. Dillard	14					New pool
37	J. Stewart & Co., Inc.	1,440	990/1	1/2 on 2	400	250	New pool
38	J. Stewart & Co., Inc.	31					New pay, old pool
39	The Texas Co.	48			50	500	Ext. to K.M.A.-Ellenb.
40	Fain & McGaha	252	420/1	20/64 on 2	400	260	New pool
41	J. E. Gray	5					New pool
42	Burk Royalty Co.	355		3/8 on 2	600		New pool
43	L. T. Burns	150					New pay, old pool
44	T. D. Humphrey	75	6,108,000				New pay, old pool
45	Kerlyn Oil Co.	816	670/1	1/8 on 2		580	New pool
46	Standard (Ohio)	805	1,100/1	3/4 on 2	180	75	New pool
47	Henry Zweifel	35	750,000				New pay, old pool
		19,146					

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944	74*	15*
Number of oil wells completed during 1944	630	47
Number of gas wells completed during 1944	8	3
Number of dry holes completed during 1944	602	216

* Actually making hole at close of year.

Oil and Gas Production in North Central Texas in 1944

By V. C. Perini, Jr.,* Member A.I.M.E.

The 1943 designation of districts for the Transactions† has caused some confusion because of the elimination of the West Central Texas district and the allocation of the counties of this district to the North Texas district and the North Central Texas district. The North Central Texas district as herein defined includes the counties of Brown, Callahan, Coleman, Comanche, Coryell, Eastland, Erath, Fisher, Hamilton, Hood, Jones, Lampasas, Mills, Nolan, Palo Pinto, Parker, San Saba, Shackelford, Stephens, Stonewall, Summerville, Taylor, Throckmorton and Wise.

These counties as listed are the counties of District 7B, State Railroad Commission. This district covers the south central crest and the west flank of the Bend flexure north of the Llano uplift. The west flank of the Bend flexure is on the east boundary of the Permian Basin of West Texas. The North Texas district, District No. 9, State Railroad Commission, includes the counties of Archer, Clay, Cooke, Foard, Hardeman, Jack, Knox, Montague, Wichita, Wilbarger and Young. The area of this district covers the crest and south flank of the Red River uplift and the north central crest of the Bend flexure.

The greater part of the oil and gas produced in the past from the North Central Texas district has been from Pennsylvanian strata. Some oil and gas has been produced from the lower Permian (by the latest selection of the Pennsylvanian-Permian boundary[1]) and minor amounts from the Mississippian and Ordovician sediments. Increasingly important quantities of oil and gas are to be expected from the older sediments by deeper development in proven fields and by new discoveries. Most of the oil and gas in the district has accumulated in localized, well-defined structural traps in limestone and sandstone reservoirs and in traps due to stratigraphic changes in sedimentation, mainly porosity traps in limestone and sandstone lenses, both usually associated with some structural feature.

The Stripper Well Premium Plan as adopted by the office of the Federal Price Administrator has been an aid to the producers of stripper wells. The producers are pleased to receive the subsidy to prolong the plugging of wells, but they are not too pleased with the subsidy plan in principle. Most independent operators are in favor of, and think they are entitled to, an increase in the market price for oil. The price is not adequate to meet the requirements of the average independent operator with the continued advance in production, development and wildcatting costs.

Old and new pipe lines for oil and gas leading out of the state are removing reserves at an alarming rate. Curves showing the rate of discovery versus production and pipe-line deliveries in and out of the state make a cross that sooner or later will be fatal to the state. Wildcatting not only needs a price increase but every other available incentive and encouragement.

Manuscript received at the office of the Institute April 6, 1945.

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† *Trans.* A.I.M.E. (1944) **155**, 469.

[1] M. G. Cheney: *Bull.* Amer. Assn. Petr. Geol. (1940) **24**, 1.

The increased allowable plan for new discoveries as adopted by the State Railroad Commission has been an incentive to wildcatting, but apparently this is not adequate to meet the demands of the wildcatters. During the past three months there has been a decrease in wildcat locations and the purchase and assembly of blocks of acreage for wildcat drilling. This is due to increased drilling costs which are the results of successful demands of labor for higher wages and also the inexperienced labor available for operations. Some contractors and operators plan to stack their tools rather than cope with the labor problem, because of the increased risks in drilling.

Production and Drilling

The total oil production, pipe-line runs, from this district during the past three years is as follows: 8,964,880 bbl. in 1942, 8,966,243 bbl. in 1943, 9,986,235 bbl. in 1944. The Railroad Commission production schedules allowed 226 producing days in 1942; 249 days in 1943, and 281 days in 1944. The increase in production over the previous years is the result of an increase in the number of producing wells, a greater demand for high-gravity sweet oil and the additional producing days. The total discoveries of oil and gas fields during 1944 are less than in previous years. Development in the newly discovered fields and in the extensions of old fields has been more rapid than in previous years, owing to increased allowables and the demand for oil. The total amount of oil and gas reserves added in 1944 by discovery and extensions does not equal the amount produced during the year. The total number of wells drilled in 1944 is greater than in 1942 and 1943, with a decrease in locations during the latter part of the year. During the year this district is credited with 12 wildcat oil discoveries, one major extension of proven fields and two new producing reservoirs in old fields.

Table 3, as prepared by the Railroad Commission of Texas, shows a comparison for the past three years. It should be used with reservations, as there still remains a wide difference of opinion as to the definition of a wildcat, a semiwildcat and an extension to a proven field. Also, it should be noted that in the shallow areas of this district, where oil is found at depths from 300 to 1500 ft. in lenticular sandstones and variable porosities in limestone, many of the wells listed as dry oil and gas wells in proven fields should be considered as wildcats. There are some other discrepancies in this table, due to incomplete records in the Railroad Commission files at the end of the year.

Discoveries and Developments

Williams Field, Coleman County

The Sohio Oil Co. and Hunter and Hunter Williams pool area has had the most active development of any area in this county. The Williams pool is in the Novice district in the northwest part of the county. Eleven oil wells and two gas wells have been drilled during this year. The discovery of the gas area was credited to 1943. The Williams No. 1-B, sec. 18, blk. 2, T. and N. O. Ry. Co. survey, topped the Gray sand at 3755 ft. This sand is a member of the Strawn formation of Pennsylvanian age, and is the same sandstone that is producing in the Silver Valley and Jim Ned pools of this district. The sand is 44 ft. thick in this well and estimated to be 50 per cent saturated and effective. On potential test the well flowed 880 bbl. of 46° gravity oil in 24 hr. through a ¾-in. choke. The gas-oil ratio was 610, casing pressure 400 lb. and tubing pressure 100 pounds.

The average effective estimated thickness of the Gray sand producing reservoir is 15 ft. Three wells cored saturated shallow Gardner sandstone, and an attempt will be made to dually complete these two reservoirs. The average interval between

TABLE 1.—*Oil and Gas Production in North Central Texas in 1944*

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production[1] Millions Cu. Ft.[e] To End of 1944	Gas Production[1] Millions Cu. Ft.[e] During 1944	Number of Oil Wells[f] Completed to End of 1944	Wells Producing[g] Dec. 1944, Oil: Flowing	Wells Producing[g] Dec. 1944, Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Av. Ft. Bottoms Prod. Wells	Producing Formation: Structure[o]
	BROWN COUNTY																
1	Brownwood, East*	1919	1,600			2,467.1	282.3				13		Big Saline, Pen	L		1,700	A
2	Brownwood, West*	1927	1,800			2,550.6	431.7				30		Big Saline, Pen	L		15–1,700	A
3	Byler	1926	300	872,374	3,912			20				39	Fry, Pen	S		1,300	AL
4	Byrd Store	1920	400	408,952	2,062			7				37	Big Saline (Bend), Pen	L		2,450	A
5	Childress	1927	300	948,667	21,849			59				35	Childress, Pen	S		800	AL
6	Clark-Buffalo	1927	460	841,457	14,571			28				42	Fry, Pen	S		1,150	NL
7	Cross Cut Area	1921	2,300	6,609,247	57,067			132				40	Cross Cut, Pen	S		1,200	NL
8	Fry	1925	940	8,141,538	59,082			83				42	Fry, Pen	S		1,300	NL
9	George	1927	200	971,046	29,231			31				39	Fry, Pen	S		1,300	NL
10	Jannellan*	1918	1,600			7,110.5	635.6				24		Caddo, Pen	L		1,100	A
11	Salt Creek*	1928	1,500			411.4	230.5				6		Big Saline, Pen	L			A
12	Smith Ellis	1926	450	2,499,957	35,076			36				41	Fry, Pen	S		1,300	NL
13	Stover	1926	1,500	7,870,155	105,274			155				41	Blake, Pen	S		1,200	NL
14	Others	1917	5,800	2,945,232	54,287								Pen	SL	100	3,000	
15	Total Brown County		19,150	32,108,625	382,411			794	7	787	78						
	CALLAHAN COUNTY																
16	Baum	1925	500	952,618	7,176			18				39	Cross Plains, Pen	S		1,780	NL
17	Hatchett	1927	375	1,528,367	22,848			80				38	Moutray, Per	S		400	NL
18	Isenhour	1923	600	2,305,754	8,071			119				37	Isenhour, Per-Pen	S		700	NL
19	Moutray	1926	400	2,773,200	46,533			89				37	Moutray, Per	S		750	DL
20	Scranton	1939	160	108,586	7,119			8			6		Cathey, Pen	S		1,675	NL
21	Others	1920	9,620	8,025,929	127,001			799					Moran to Ellenburger, Per-Ord	SL	150	4,300	
22	Total Callahan County		11,655	15,694,454	218,748			1,113	6	1,007	6						
	COLEMAN COUNTY																
23	Ansac, Morris	1937	200	298,022	44,928			14				44	Morris-Cross Cut, Pen	S		2,100	NL
24	Burkett, Shallow	1924	850	2,650,992	54,428			173				34	Burkett, Pen	S		400	NL
25	Burkett, Deep	1930	160	734,555	5,598			17				41	Cross Cut, Pen	S		1,550	NL
26	Coker	1942	400	328,907	166,537			13	13	0		42	Morris, Pen	S		3,060	NL

27	Dibrell, Gayle	1926	320	590,996	25,202			17				42	Morris, Basal Big Saline, Pen	S-Cg	1,900	3,200	NL
28	Eastland	1927	270	2,185,018	23,104			22				42	Up, Fry, Pen	S		2,000	NL
29	Goldsboro	1927	260	1,131,958	51,624	3,116.8	204.2	10	7	3		42	Gardner, Gray, Pen	S	3,850	3,975	TL
30	Jennings	1926	160	528,992	8,414			25				32	Jennings, Pen	S		1,200	NL
31	Jim Ned (Jim Ned*)	1941	200	40,270	13,092	674.6	204.8	2	2	0	4	42	Morris-Gray, Pen	S	3,400	3,900	TL
32	Morris*	1925	1,000			450.9	0.7	3			3		Morris, Pen	S		2,200	A
33	Novice	1927	1,050	1,228,669	154,396			48	48	0		41	Gardner, Pen	S		3,600	TL
34	Overall	1927	340	1,491,549	40,917	600.9	77.3	7				42	Cisco-Canyon-Strawn(s), Pen²	S		2,100	DL
35	Santa Anna (Santa Anna*)	1915	240	497,625	10,173	5,484.6	1,899.3	10			38	39	Fry-Big Saline (gas), Pen	S	1,500	2,200	NL
36	Silver Valley	1941	640	325,974	114,997			13	13	0		43	Gray, Pen	S		3,600	NL
37	Stewardson	1929	240	476,519	7,509			14				40	Fry-Gardner, Pen	S		1,450	NL
38	Valera*	1918	1,500			1,411.6	96.1				2		Gray, Pen	S		3,100	NL
39	Williams	1944	500	72,775	72,775			11	11		2	42	Gray, Pen	S		3,755	NL
40	Others	1910	1,000	1,228,398	20,331						1		Pueblo-Ellenburger, Per-Ord	SL	400	3,850	
41	Total Coleman County		9,330	13,811,219	814,025			422	106	316	50						
	Comanche County																
42	Amity	1939		357,100	59,527			63				38	Blake, Pen	S		600	NL
43	Sipe Springs*	1919	1,500			6,453.0	0.3				25		Big Saline, Pen	L		2,700	A
44	Sipe Springs	1919	800	735,928	21,900			16				39	Sipe Springs, Pen	S		350	NL
45	Others			898,656	7,198	668.0x							Strawn-Bend-Ellenburger, Pen-Ord	SL	300	4,000	
46	Total Comanche County		2,300	1,991,684	88,625			140	6	134	33						
	Comanche, Eastland, Erath Counties																
47	Desdemona	1918	6,020	23,891,178	120,134			57				40	Desdemona (Big Saline), Pen	S		2,750	DL
	Eastland County																
48	Carbon	1939	200	91,427	8,096			7				40	Caddo Pool Blk, L, Pen	L		2,600	NC
49	Cisco*					1,758.0	82.6				23						
50	Eastland*	1923	80			3,251.7x					6		Lake, Pen	S		3,000	
51	Hilburn	1919	420	1,158,014	10,115			5				31	Big Saline, Pen	L		3,100	A
52	Leeray*	1927				35,348.5	3,800.6				50		Strawn-Big Saline, Pen	S	1,950	3,800	
53	Mangum	1922	300	1,074,890	23,809			49				38	Strawn, Pen	S		1,200	NL
54	Pioneer	1919	1,400	5,751,435	43,926			53				41	Pioneer (Parks), Pen	L		2,450	AF
55	Ransour	1926	250	1,612,304	26,827			8				38	Big Saline, Pen	S		3,600	N
56	Thorpe*	1936	160			276.9	209.3						Strawn, Pen	S		1,700	
57	Others	1917	28,000	67,476,318	560,837			289			30						
58	Total Eastland County		30,810	77,164,388	673,610			411	30	381	109						
	Erath County																
59	X-Ray*	1920	5,600			14,910.8	936.8				34		Big Saline (Ranger), Pen	SL		3,225	A
60	Others*										3						
61	Total Erath County										37						

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production[1]		Number of Oil Wells[f]	Wells Producing[g] Dec. 1944			Character of Oil[i]	Producing Formation				
			Area Proved, Acres[b]	Total Production, Bbl.[c] To End of 1944	Total Production, Bbl.[c] During 1944	Millions Cu. Ft.[e] To End of 1944	Millions Cu. Ft.[e] During 1944	Completed to End of 1944	Oil Flowing	Oil Artificial Lift	Gas	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Av. Ft. Bottoms Prod. Wells	Structure[o]
	FISHER COUNTY																
62	Howard	1934	400	226,185	14,298			7				38	Upper Hope, Canyon, Pen	L	3,670	5,587	AD
63	McCaulley	1941	200	172,685	60,115			9				42	Camp Colorado-Upper Hope, Per-Pen	L		3,330	NC-AC
64	Rotan	1936	640	1,479,302	69,095			31				38	Camp Colorado, Per	L		3,500	NC
65	Rotan, West	1937	80	78,554	5,042			2				39	Camp Colorado, Per	L		3,600	NC
66	Royston	1928	2,900	12,342,240	286,930			95				39	Royston (Flippen), Pen	L		3,100	A
67	Total Fisher County		4,220	14,298,966	435,480			144	1	143							
	HAMILTON COUNTY																
68	Pottsville	1936	800			967.7	405.5				5		Big Saline (Marble Falls), Pen	L	2,600	2,800	A
	HASKELL COUNTY																
69	Lawson	1942	80	12,388	6,614			2	1	1		40	Canyon (Reef), Pen	L		2,685	D
70	Moody	1928	80	131,247	4,229			6				38	Hope, Pen	S		1,800	NL
71	Pardue	1938	80	80,062	5,339			3				39	Upper Canyon, Pen	L		2,850	A
72	Others		10	12,072	1,000												
73	Total Haskell County		250	235,769	16,182			12	1	11							
	JONES COUNTY																
74	Akard	1938	500	508,234	110,955			31	10	21		39	Flippen, Per	S		2,150	AL
75	Appling	1939	80	73,838	2,795			2		2		36	King-Swastika, Pen	S		2,640	NL
76	Alexander	1944	160	32,729	32,729			8		8		38	Bluff Creek, Pen	S		1,647	NL
77	Avoca	1935	740	3,135,087	564,690			51	41	10		42	Palo Pinto, Pen	L		3,260	A
78	Avoca, Griffen	1936	640	3,207,365	557,706			60	39	21		42	Palo Pinto, Pen	L		3,240	A
79	Avoca, North	1938	260	282,556	91,409			9	9			42	Palo Pinto, Pen	L		3,240	A
80	Avoca, West	1941	80	49,886	11,912			3		3		42	Palo Pinto, Pen	L		3,245	A
81	Dorsey, Hawley	1933	600	3,434,787	79,592			65		65		39	L. Per-U. Cisco (8), Per-Pen	SL	1,900	2,300	DL

82	Guitar, Hawley	1936	400	866,171	19,155			35				37	Flippen S-L-U. Hope, Pen	SL		2,000	AL
83	Hardy	1943	40	94,694	92,953			5		5		40	Canyon, Pen	S	3,690	3,715	NL
84	Jennings-Lueders	1934	160	607,417	5,388			13				39	King, Pen	S		2,040	A
85	Lewis-Steffins	1936	1,500	2,753,381	97,371			164	3	161		38	Bluff Creek, Per	S		1,900	NL
86	Noodle Creek	1927	1,030	7,413,033	117,260			50				38	Camp Colorado, Per	L		2,500	AC
87	Noodle Creek, Irvin	1937	500	588,195	95,184			21				39	Camp Colorado-U. Cisco, Per-Pen	LS	2,350	3,000	AL
88	Noodle Creek, South	1941	360	276,536	122,261			14	4	10		44	Camp Colorado-Swastika, Per-Pen	LS	2,726	2,950	AC
89	Noodle Creek, Central	1943	300	155,196	128,320			11	8	3		39	L. Hope-Swasika, Pen	LS	2,735	3,000	A
90	Sandy Ridge, Higgs	1926	500	468,670	33,203			25				37	Bluff Creek, Per	S		1,900	NL
91	Sayles	1932	900	2,904,761	261,939			93	13	80		41	Flippen, Per	S		1,950	TNL
92	Stith	1940	160	86,296	40,487			7	4	3		42	Flippen-Hope-Gunsight, Per-Pen	SL	2,350	2,670	AL
93	Strand (Jones and Haskell)	1941	400	151,292	80,859			7	4	3		36–41	Palo Pinto, Pen	L		3,400	A
94	Triplett	1940	160	83,098	5,859			3		3		36–42	Flippen S-L Hope, Pen	SL	2,190	2,700	AL
95	Wimberly	1941	1,570	1,529,095	901,103			72-32D[3]	55-32D	16-1D		38–45	L-Per-U. Cisco (?), Pen	SL	2,100	2,600	AL
96	Others	1926	340	452,100	41,793												
97	Total Jones County		11,380	29,154,417	3,494,923			766-32D	193-32D	572-1D							
	Palo Pinto County																
98	Boles*	1943	160			1,509.2					2		Ranger, Pen	S		3,360	
99	Brad*	1922	320			3,522.5	161.1				2		Big Saline, Pen	S		3,750	A
100	Gordon*	1932	400			739.8	0.6				3		Big Saline, Pen	S		3,100	NL
101	Lone Camp*	1929	500			941.1	44.8				1		Big Saline, Pen	S		3,550	NL
102	Marston, Spur*	1922				522.2	42.5				2		Big Saline, Pen	S		3,200	N
103	Nolan*	1941	160			118.4	22.9				1		Big Saline, Pen	S		3,465	
104	Rector*					1,930.9	431.9				4						
105	Ringo					229.4	30.0				2						
106	Strawn (Strawn*)	1915	1,200	3,124,601	36,477	29,835.6	1,070.8	80			31		Strawn-Big Saline, Pen	SL		3,000	NL
107	Others		1,500	2,210,250	40,028			34			15						
108	Total Palo Pinto County		4,240	5,334,851	76,505			114	4	126	63						
	Shackelford County																
109	Bluff Creek	1930	1,100	4,762,008	202,009			253			2	37	Bluff Creek, Per	S		1,600	TL
110	Cook Ranch	1925	1,620	18,805,391	539,098			404				37	Cook, Pen	S		1,200	TL
111	Frye	1925	120	361,348	3,969			59				35	Frye, Per	S		450	NL
112	Hope	1923	220	1,596,268	53,946			57				37	Hope, Pen	S		1,500	NL
113	Ibex	1921	1,240	2,517,162	17,438	59,775.4	1,161.3	20			17	39	Ibex, Pen	L		3,500	A
114	Ivy (Deep and Shallow)	1937	900	2,655,463	402,704			80	25	55		39	Cook, King, Palo Pinto, Pen	SL	1,700	3,200	A
115	Nail	1927	540	832,085	126,751			48		48		40	Bluff Creek, Cook, Per-Pen	S		1,400	NL
116	Newell	1924	700	1,036,913	43,158			81				37	Tannehill, Per	S		1,100	NL
117	Simmons-Harvey	1925	160	490,831	15,013			20				39	Bluff Creek, Per	S		1,700	NL
118	Tannehill-Mathews	1927	300	2,705,649	71,867			62				38	Tannehill, Per	S		1,150	NL
119	Others	1911	6,580	11,960,369	293,634								Wolfcamp-Ellenburger, Per-Ord	SL	200	4,600	
120	Total Shackelford County		13,480	47,723,487	1,769,587			1,994	27	1,967	31						

TABLE 1.—(*Continued*)

Line Number	Field, *County*[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production[1]: Millions Cu. Ft.[e] To End of 1944	Gas Production[1]: Millions Cu. Ft.[e] During 1944	Number of Oil Wells[f]: Completed to End of 1944	Wells Producing[g] Dec. 1944: Oil, Flowing	Wells Producing[g] Dec. 1944: Oil, Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Av. Ft. Bottoms Prod. Wells	Structure[o]
	STEPHENS COUNTY																
121	Caddo, North*	1938				678.1	286.6				4		Big Saline, Pen	L		4,000	
122	Caddo, South*	1928				297.2	33.4						Strawn, Pen	S		2,200	A
123	Curry	1921	2,600	10,036,878	92,219			51				38	Up. Parks, Fm., Pen	L		3,100	A
124	Frankel*					1,286.6	28.0				2				2,118	3,514	
125	Hohertz, Strawn	1915	850	4,891,467	48,422			84			12	39	Strawn, Pen	S		1,850	MLN
126	La Casa					4,070.2	107.5				5						
127	Loving (Eolian)	1939	360	238,653	46,929			16	11	5	4	43	Up. Parks, fm., Pen	L		3,500	A
128	Stribling	1939	320	210,576	14,501			11		11		42	Up. Parks, fm., Pen	L		3,600	A
129	Wild	1944	300	80,525x	80,525x			7	7				Ellenburger, Ord	L		4,400	A
130	Wiles*	1930	400			383.9	30.7				1					3,640	
131	Others	1916		117,053,263	989,663			61					Strawn, Bend, Mis., Ell., Pen-Ord	LS	1,900	4,500	
132	Total Stephens County			132,511,362	1,272,259			627	51	576							
	STONEWALL COUNTY																
133	Aspermont	1940	80	45,378	4,845			2		2		40	Strawn, Mis, Pen-Mis	LS	4,150	6,060	A
134	Boyd	1939	40	43,209	8,158			2		2		39	Palo Pinto, Pen	L		4,725	A
135	Carlisle	1938	100	142,543	18,401			2		2		41	Palo Pinto, Pen	L		5,175	AL
136	Total Stonewall County		220	231,130	31,404			6		6							
	TAYLOR COUNTY																
137	Bowles	1937	120	112,578	2,459			2		2		38	Cook, Pen	S		1,750	NL
138	Merkel	1941	280	227,040	94,654			13		13		38	Dothan, L. Hope, Per-Pen	L	2,020	2,625	D
139	Reddin	1942	125	329,739	200,286			5-3D	4-3D	1		40	Wolfcamp, U. Cisco (4), Per-Pen	L	2,250	2,500	D
140	South View	1940	240	233,159	31,232	649.3		12	5	6	7	36	Flippen, Pen	L		2,400	D
141	Trent	1942	80	16,167	1,584			2		2		42	Saddle Creek, Pen	S		2,770	N
142	Others	1929	340	498,329	25,444								Wolfcamp-Cisco, Per-Pen		1,600	3,000	
143	Total Taylor County		1,185	1,417,012	355,659			56-3D	12-3D	44							

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production[1]		Number of Oil Wells[f]	Wells Producing[g] Dec. 1944			Character of Oil[i]	Producing Formation				
			Area Proved, Acres[b]	Total Production, Bbl.[e]		Millions Cu. Ft.[e]			Oil								
				To End of 1944	During 1944	To End of 1944	During 1944	Completed to End of 1944	Flowing	Artificial Lift	Gas	Gravity A.P.I. at 60°F.	Name and Age[j]	Character[k]	Depth to Top of Producing Zone, Ft.[m]	Av. Ft. Bottoms Prod. Wells	Structure[o]
	THROCKMORTON COUNTY																
144	McKnight	1941	160	64,326	18,939			2	1	1		40	Parks, Pen	L		4,050	A
145	Parrott	1941	80	32,799	14,053			2	1	1		40	Parks, Pen	L		4,020	A
146	Woodson, Deep	1929	320	2,018,363	37,968			11			1	38	Parks, Pen	L		3,900	A
147	Woodson, Shallow	1926	200	820,242	11,880			6				37	Canyon-Strawn (3), Pen	S	1,750	3,150	A
148	Others	1924	1,000	1,356,474	154,843								Cisco-Chapel, Pen-Mis	SL	300	4,500	
149	Total Throckmorton County		1,760	4,292,204	237,683			276	4	272							
	WISE COUNTY																
150	Park Springs	1942		1,463	Abandoned 1944							39	Big Saline, Pen	S		5,818	

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Gas withdrawals by Lone Star Gas Co. and Community Natural Gas Co.
[2] Figures in parentheses indicate number of productive reservoirs.
[3] 32 dually completed wells.

the two sandstones is 200 ft. The Gardner sand is the same sandstone that is producing in the Novice and Goldsboro pools in the Novice district. The Williams pool has added 500 proved acres to the Novice productive area and at least 400 additional productive acres should be developed during 1945. The pool was located by core drilling, which outlined a plunging anticlinal nose with flattening. The nosing is accentuated with depth and the sandstone lens is associated with this structural feature.

Howard Field, Fisher County

The Northern Ordnance, Inc. Howard B-1, sec. 180, blk. 2, H and T. C. Ry. Co. survey, at a depth of 5680 ft., discovered a new producing reservoir in this county. This is a deeper pay reservoir in the Howard pool at Rotan, and a part of the Howard-Rotan plunging anticline, which

TABLE 2.—*Summary of Drilling Operations in North Central Texas*

Important Wildcats Drilled in 1944

	County	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. Per Sq. In.		Remarks
		Sec.	Blk.	Survey					Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		Casing	Tubing	
1	Coleman....	18	2	T. & N. O.	3,799	Cre	Strawn Pen	Sohio, Hunter & Hunter	880	0.5	¾	400	100	Discovery, Pen Gray S 3755 to 3799
2	Coleman....	3	1	H. & T. C.	2,852	Cre	Strawn Pen	States Oil Corporation	37	0.1	¾	480	200	Discovery, Morris S 2820 to 2840
3	Fisher......	180	2	H. & T. C.	5,630	Per	Canyon? Pen	Northern Ordnance, Inc.	602		½	725	125	New Producing Reservoir Pen Canyon, 5587 to 5630
4	Jones.......	3	14	T & P	1,658	Per	Wolfcamp Per	Cardinal, Contex Petr. Corp.	126		Pump			Discovery, Per Bluff Creek S 1648 to 1658
5	Jones.......	Surv. No. 263		Henry Virm	2,820	Per	Cisco Pen	Esson Oil Company	15		Pump			Discovery, Pen "Gunsight" L 2793 to 2797
6	Jones.......	6	17	T. & P.	2,474	Per	Cisco Pen	Alder Oil Co. and Merry Bros. & Perini	80		Pump			Discovery, Pen Cook S 2463 to 2470
7	Jones.......	19	2	T. & N. O.	2,388	Per	Cisco Pen	Alder Oil Co. and Merry Bros. & Perini	388		Pump			Discovery, Pen Flippen L 2384 to 2388
8	Jones.......	25	17	T. & P.	2,571	Per	Cisco Pen	NewIdriaQuicksilver Mfg. Co.	344		Pump			Extension, Wimberly Pen "Gunsight" L 2569 to 2571
9	Stephens....	1,142	A 537	T. E. & L.	3,236	Per	Bend Pen	Northern Ordnance, Inc.	101 101	0.9 0.9	¼ ¼	860 860	640 640	Discovery, Pen Big Saline L 3222 to 3236
10	Stephens....	58		B. A. L.	4,375	Per	Ellenburger-Ord	Phillips Petr. Corp.	672	0.6	5⁄64	500	600	Discovery, Ord Ellenburger L 4354 to 4369
11	Taylor......			Wm. Bishop	2,508	Per	Cisco Pen	Great Lakes Carbon Corp.	25		Pump			Discovery, Pen Flippen L 2001 to 2038
12	Taylor......	Survey No. 122		Wm. R. Willis	2,785	Per	Cisco Pen	Texas Company	51		Pump			Discovery, Pen Flippen L 2276 to 2284
13	Throckmorton.	Survey No. 2		B. & B.	817	Per	Cisco Pen	Grisham & Hunter	128		Pump			Discovery, Pen Cisco S 812 to 817
14	Throckmormorton.			T. E. & L.	5,034 P.B.[1]	Per	Ellenburger-Ord	Panhandle Ref. Corp.	744	0.5	⅜	760	250	Discovery, Pen Bend L 4156 to 4162

[1] Plugged back.

was located by surface geological detail. The saturated limestone from 5587 to 5630 ft. was treated with 2000 gal. acid, which resulted in a well flowing 602 bbl., 40° gravity oil per day through a ½-in. choke with a casing pressure of 725 lb., and a tubing pressure of 125 lb. The well flowed for a period of three days and refused to flow further. After many days of experimenting, the well was placed on the pump and is now producing 45 bbl. of oil per day. Three other wells were drilled to the same reservoir; that is, two dry holes and one small producer. The dry holes were down the north and west flank of the structural feature.

TABLE 3.—*Drilling, Completion and Plugging Summary, North Central Texas*[a]

Year	1942	1943	1944
Regular drilling applications	490	507	610
Rule 37 Applications:			
Granted	28	20	16
Denied	0	0	0
Oil well completions	188	163	205
Gas well completions	17	18	20
Dry holes	179	247	181
Wildcats drilled:			
Oil	17	7	28
Gas	5	2	3
Dry	95	135	133
Wells plugged:			
Oil	152	106	182
Gas	24	13	8
Dry	155	213	242

[a] Railroad Commission of Texas, Oil and Gas Division.

The age and correlation of the new reservoir has not been definitely determined, but it is thought to be either a part of the Palo Pinto limestone formation of the Canyon series or a limestone of the Strawn series, both of Pennsylvanian age. The reservoir correlates approximately, on a lithological basis, with the producing reservoir of the Avoca pool in Jones County, the Shell Rutherford pool in Stonewall County and the recent discovery by the Ohio Oil Co. in King County. The production from these pools is considered as a part of the Palo Pinto formation, or the underlying Strawn series. Only more drilling will ascertain the real value of this new producing reservoir, but it should be one of the deep objectives for wells drilled on structural features in this district.

Wimberly Field Extension, Jones County

The New Idria Quicksilver Mining Co., Kelso No. 1, sec. 25, blk. 17, T. and P. Ry. Co. survey, is a one-mile southwest extension well of the Wimberly pool. The "Gunsight" limestone reservoir was topped at 2569 ft., and is of the Cisco formation of Pennsylvanian age. The well pumped 344 bbl. in 24 hr. after a treatment with 2000 gal. of acid. Since this extension discovery, 18 wells have been drilled between this well and the Wimberly pool, of which all but five are dually completed. The two producing reservoirs are the "Lower Hope" and the "Gunsight" limestones, separated by an interval of 125 ft. On potential test, after acidization, the "Lower Hope" limestone reservoir flows between 20 and 50 bbl. of 40° gravity oil per hour, and the "Gunsight" limestone reservoir flows between 40 and 100 bbl. of 42° gravity oil per hour. The Saddle Creek replacement sandstone, the Saddle Creek limestone and the Flippen limestone reservoirs produce in some of the wells in the new extension area.

Approximately 320 proved acres have been added to the reserve acreage of the Wimberly pool by the drilling of this extension well. The Wimberly pool produced more than 900,000 bbl. of oil during 1944 and is one of the outstanding shallow oil pools in West Texas. It produces from five to eight different reservoirs in the lower Permian and Pennsylvanian formations at a depth of 2200 to 2600 feet.

Alexander Field, Jones County

The Cardinal Oil Co., Contex Petroleum Corporation et al. No. 1 Alexander is a wildcat oil discovery in sec. 3, blk. 14, T. and P. Ry. Co. survey. This location was made by the aid of structural subsurface geology and subsurface mapping

of the Bluff Creek sandstone, the most prolific producing sand reservoir in the local area of the discovery. The sandstone is of Wolfcamp, Permian age. The oil accumulation in this sandstone lens is associated with anticlinal nosing. Eight wells have been completed on a 10-acre spacing pattern and, to date, 160 acres are considered as the proved acreage reserve. The average thickness of the sandstone is 14 ft., of which 50 to 70 per cent is considered to be saturated and effective. The average depth to the top of the sandstone is 1650 ft. The few wells drilled indicate that this pool may be an important reserve for the county.

Wild Field, Stephens County

The discovery and development of Wild field by the Phillips Petroleum Co. created considerable interest throughout the Shackelford-Stephens County area during 1944. The discovery well, No. 1 Wild, sec. 58, B. A. L. survey, Stephens County, topped the Ellenburger dolomite of Ordovician age at 4354 ft. There was only a slight show of oil after the casing was set, cemented, and the plug drilled. The well was then treated with 2000 gal. of acid, after which it produced by flowing through a 5⁄64-in. choke, 672 bbl. of 44.5° gravity oil in 24 hr., with a tubing pressure of 600 lb. and a casing pressure of 500 lb. The oil occurs in vugs and joint planes in the crystalline dolomite, which is only partially saturated. The thickness of the pay reservoir has not been determined and no estimates are available as to the oil reserve in this reservoir.

The Wild pool is southeast of the Ibex pool in Shackelford County and on the same structural trend. The seven wells drilled in the Wild pool indicate a gentle anticlinal structure; the amount of closure, as yet, has not been determined. The pool is being developed with a pattern of 40 acres to each well and 300 acres have been developed as proved acreage.

This is an important discovery and the development is being watched with interest. The Ellenburger dolomite has been considered for many years as a potential valuable oil and gas reservoir, but comparatively few wells have tested the formation, since it has produced oil profitably in very few wells in the district. Only the drilling of additional wells to the Ellenburger reservoir will ascertain its real value, but it is thought that with the encouragement of the Wild pool future wells will commence with this reservoir as an objective, provided there are indications of structural prominences sufficient to warrant deeper drilling.

Throckmorton County

Throckmorton County has had an increase in activity during this year. There have been two discoveries that may be important after development.

The Panhandle Refining Corporation, No. 1 Ewalt in the T. E. and L. survey, after drilling to the Ellenburger dolomite at 5034 ft., plugged back and completed a well in the "Caddo" lime, Bend group, of Pennsylvanian age. The limestone is saturated from 4156 to 4162 ft., and after acidization with 1000 gal., the well flowed at the rate of 744 bbl. of 42° gravity oil in 24 hr. through a 3⁄8-in. choke, with a casing pressure of 760 lb., and a tubing pressure of 250 pounds.

Grisham and Hunter, Kelly No. 2, survey No. 2 Brooks and Burleson, pumped 128 bbl. of 36° gravity oil from a Cisco sandstone at 812 feet.

Acknowledgments

The writer is indebted for information and assistance in preparing this report to T. F. Petty, C. H. Irvin, Humble Oil and Refining Co.; Vaughn Moore, Roeser and Pendleton; L. T. Potter, A. E. Brown, Lone Star Gas Co.; M. G. Cheney, and the personnel of the District and State Railroad Commission.

Oil and Gas Development in the Texas Panhandle in 1944

By H. W. McCue*

In 1944, in the Texas Panhandle, 245 oil wells were drilled with a total daily initial production of 32,886 bbl., representing an average initial production of 134 bbl. per well. This was an increase over 1943 of 121 wells drilled, and an increased initial production of 13,861 barrels.

On Dec. 31, 1944, the field was operating on an allowable of 113,567 bbl. per day, but actually was producing 85,539 bbl. per day from the 5901 oil wells.

The total production for the year was 33,439,436 bbl., bringing the cumulative total to 504,537,048 barrels.

Gas

Sixty-three gas wells with a combined open flow of 992 million cu. ft., were drilled during 1944. This was an increase of seven wells over 1943, but a drop of 216 million cu. ft. in initial open flow. The

Manuscript received at the office of the Institute April 3, 1945.

* Columbian Fuel Corporation, Amarillo, Texas.

Table 1.—*Oil and Gas Production in the Texas Panhandle*

Line Number	Field, County[a]	Year of Discovery	Oil Production			Gas Production			Number of Oil and/or Gas Wells[f]		
			Area Proved, Acres[b]	Total Production, Bbl.[c]		Area Proved, Acres[d]	Millions Cu. Ft.[e,f]		Completed to End of 1944	1944	
				To End of 1944	During 1944		To End of 1944	During 1944		Completed	Abandoned
1	Carson	1921	19,570	50,973,397	4,305,124	247,194	*x*	*x*	1,133	51	1
2	Gray	1925	60,445	231,688,653	16,485,824	227,127	*x*	*x*	3,119	117	3
3	Hansford*	1937	0	0	0	60,000	*x*	*x*	11	10	0
4	Hartley*	1928	0	0	0	32,000	*x*	*x*	8	4	0
5	Hutchinson	1922	64,793	189,539,615	11,346,697	217,071	*x*	*x*	3,264	89	15
6	Moore*	1926	640	5,611,501	161,443	439,630	*x*	*x*	520	26	
7	Potter*	1919	0	33,822	0	144,786	*x*	*x*	62	0	0
8	Sherman*	1938	0	0	0	350,000	*x*	*x*	11	6	0
9	Wheeler	1925	8,250	24,481,810	1,140,348	153,768	*x*	*x*	828	3	12
10	Total		153,698	502,328,798	33,439,436	1,871,576	12,222,170	801,371	8,956	306	31

[a] Footnotes to column heads and explanation of symbols are given on page 258.
Gas measurement pressure base 14.65 pounds.

drop is partly accounted for by increased exploratory drilling along the edges of the field and in areas of light production.

The gas production showed a decided increase over the past several years, and amounted to 801,371 million cu. ft. for the year, bringing the total cumulative production to Dec. 31, 1944 to slightly under 12.25 trillion cu. ft. Several hundred thousand acres of additional gas production were added to previous estimates, partly by extensions in Hartley and Moore Counties and partly by exploratory work in Hansford and Sherman Counties. Parts of the latter counties had been considered for some years as probably productive, but 1944 marked the start of major drilling.

Pipe-line Gas

The pipe-line companies withdrew a total of 340,391 million cu. ft. of gas for the year, or a daily average of slightly over 930 million cu. ft. per day. This was a total for the year of almost 12.5 billion cu. ft. more than was withdrawn in 1943.

Natural Gasoline

Forty gasoline plants operated during 1944 processing 663,892 million cu. ft. of gas, and recovering 8,041,400 bbl. (337,738,800 gal.) of natural gasoline. The daily capacity of these plants is slightly in excess of 2.5 billion cu. ft. of gas per day.

Carbon Black

At the end of the year 30 carbon black plants were operating in the Panhandle.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil, Most Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Reservoir Pressure, Lb. per Sq. In.: Initial	Reservoir Pressure: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	694		430	*x*		39	0.06	Big Lime Series (Wichita), Per-Pen	D, D, A LA	*x*	3,000	40	AF		
								Granite Wash (Cisco), Pen	Gw					Granite Wash (E. Zone)	*x*
2	2,609		430	*x*		39	0.04	Big Lime Series (Wichita), Per-Pen	D, D, A LA	*x*	3,100	50	AF		
								Granite Wash (Cisco), Pen	Gw	*x*	2,850	30	AF	Granite Wash (E. Zone)	*x*
3		9	430	*x*				Big Lime Series, Per-Pen	L, D D, A	*x*	2,800	30	AF	Pen	4,595
4		8	430	*x*				Big Lime Series, Per-Pen	D-L D, A	*x*	3,100	30	AF	Granite Wash	4,000
5	2,171		430	*x*		35	0.08	Big Lime Series (Wichita), Per-Pen	L, D	*x*	2,800	40	AF		
										x	3,200	40	AF		
								Granite Wash, Pen	Gw, L	*x*	3,000	40	AF	Arbuckle	4,333
6	17		430	*x*		31	0.08	Big Lime (Wichita), Per-Pen	L, D			40	AF		
								Granite Wash (Cisco), Pen	Gw	*x*	2,500	40	AF	Arbuckle	8,013
7			430	*x*		*x*		Big Lime (Wichita), Per-Pen	L						
								Granite Wash (Cisco)	Gw	*x*	2,000	30	AF	Granite Wash (E. Zone)	*x*
8		11	430	*x*				Big Lime (Wichita), Per-Pen	L	*x*	2,800	30	AF	Arbuckle	5,138
9	410		430	*x*		37	0.04	Big Lime (Wichita), Per-Pen	L	*x*	2,400	30			
								Granite Wash (Cisco)	Gw	*x*	1,900	30	AF	Arbuckle	2,957
10	5,901	1,760													

During the year these plants used 263,007 million cu. ft. of gas producing approximately 400,000,000 lb. of carbon black for the year.

Refinery Runs

The five operating refineries in this area used a total of 21,362,533 bbl. of oil for the year, a daily average of 58,367 bbl. These refineries have a capacity of 63,000 bbl. per day. Trunk lines transported 11,791,848 bbl. and tank cars 786,544 barrels.

Storage

The oil in storage decreased 719,876 bbl. from 3,523,900 bbl. the first of 1944 to 2,804,024 bbl. at the end of the year. Total storage capacity Dec. 31, 1944 was 6,691,500 barrels.

New Development

Except for the extensions and exploration work mentioned above under the heading of Gas, 1944 saw comparatively little new development. A few edge oil wells of no particular significance were drilled, and a small productive area in southwestern Gray County was discovered. The latter is considered as having added 640 acres proven for oil, but although this is the first commercial well in the area it is almost surrounded by gas wells, most of which had shows of oil ranging from a slight show to three or four barrels per day.

Wildcats

Eight wildcats were drilled as listed in Table 2 but all were disappointments, and no new productive areas were found.

TABLE 2.—*Summary of Drilling Operations in the Texas Panhandle*

Important Wildcats Drilled in 1944

	County	Location	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Remarks
1	Childress	773, H, W. & NW.	7,037	Permian	Mississippian	Humble O. & R.	Dry Hole
2	Dallam	13, 18, C. S. S.	6,779	Triassic	Pre Cambrian	Pure Oil Co.	Dry
3	Donley	7, E, D. & P.	3,355	Permian	Per-Pen	Magnolia	Dry
4	Donley	46, 20, H. & G. N.	6,753	Permian	Pre Cambrian	Stanolind	Dry
5	Oldham	307, H3, Cap Lands	7,279	Triassic	Pen	Stanolind	Dry
6	Oldham	36, H2, Lg 320	6,114	Triassic	Pre Cambrian	Stanolind	Dry
7	Potter	192, 2, A. B. & M.	4,080	Triassic	Per-Pen	Canadian River	Dry
8	Potter	78, 47, H. & T. C.	3,777	Permian	Permian	Canadian River	Dry

Oil and Gas Development in South Texas during 1944

By Harold Decker,* Member A.I.M.E., and L. B. Herring†

The area under discussion includes districts 2 and 4, so designated by the Texas Railroad Commission,‡ and comprises the following 26 counties: Bee, Brooks, Calhoun, Cameron, De Witt, Duval, Goliad, Gonzales, Hidalgo, Jackson, Jim Hogg, Jim Wells, Karnes, Kenedy, Kleburg, Lavaca, Live Oak, Nueces, Refugio, San Patricio, Starr, Victoria, Webb, Willacy, Wilson and Zapata.

Drilling and Production

The total number of wells drilled in this district during 1944 is shown in Table 5. This indicates a 41 per cent increase in all drilling over 1943. In spite of every handicap created by the war, the oil industry more than met the crisis in its drilling program in this district. Last year we thought it would be impossible to add to the total number of wells drilled in the previous year, but in spite of the lack of manpower and materials this large increase was shown.

During 1944 this district produced 124,201,978 bbl. of oil from 11,607 producing wells, whereas in 1943 it produced 88,421,693 bbl. from 11,211 producing wells. This is an increase of 35,780,285 bbl. of oil. Some decline has been shown in the older fields and undoubtedly the majority of wells in the district are producing at too high a rate. However, this district has been able to meet any demands made on it by the Petroleum Administration for War for increased production.

Manuscript received at the office of the Institute April 28, 1945.

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‡ For map, see *Trans.* A.I.M.E., (1944) **155**, 469.

Discoveries and Extensions

There was a slight decline over the preceding year in the number of wildcats drilled, but the number of discoveries increased. In most instances subsequent development has not been sufficient to arrive at preliminary valuations but it appears that the over-all oil discoveries were below normal and that the gas discoveries were relatively more important.

The Canolis and Tijerina pools, Jim Wells County, and the Dan Sullivan pool, Brooks County, appear to be the outstanding oil discoveries of the year. No important oil reserve was discovered or developed in the Wilcox horizons, although considerable wildcatting was done.

Important extensions were made at Agua Dulce and Stratton in Nueces and Kleberg Counties. Production was increased appreciably at Willimar, Willacy County, and Seeligson, Jim Wells County, in sands and areas which were apparently productive at the beginning of the year.

Refining

Most of the major work in the changing and completing of refineries was finished this past year. Some of the most modern refineries in the industry are now located in the Corpus Christi area.

Gas and Condensate

No new recycling projects were commenced during the year, nor were there any important additions to the old operations. No major gas reserve was developed, although several new discoveries suggest potential possibilities.

TABLE 1.—*Oil and Gas Production in South Texas*

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e]: To End of 1944	Oil Production: Total Production, Bbl.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
1	Adami, *Webb*	1939	400	627,427	65,753	72	0	3
2	Agua Dulce, *Nueces*	1928	35,000	7,568,715	3,465,955	411	135	
3	Agua Prieta, *Duval*	1941	20	28,085	18,273	4	3	1
4	Albercas, *Webb*	1927	300			8	0	
5	Albrecht, *Goliad*	1944		gas		1	1	
6	Almond, *Jim Wells*	1944		gas		1	1	
7	Alfred, *Jim Wells*	1938	500	825,203	183,261	24	0	2
8	Alice, *Jim Wells*	1938	1,280	3,657,675	484,634	67	3	
9	East Alice (Tom Graham), *Jim Wells*	1938	1,750	2,173,861	388,550	53	0	*x*
10	Alta Mesa, *Brooks*	1926	1,250	1,766,687	421,495	45	1	
11	Aransas Pass, *San Patricio*	1936	6,200	13,729,671	1,519,214	362		
12	Armagosa, *Jim Wells*	1931	400	gas		9		
13	Aragua, *Victoria*	1944		gas		1	1	
14	Armstrong, *Jim Hogg*	1943	100	186,667	180,713	23	21	6
15	Aviator, *Webb*	1922	955	6,355,919	79,777	233	1	
16	Baldwin (South Sapet), *Nueces*	1935	500	1,121,883	170,609	21	7	1
17	Barbacoas, *Starr*	1933	80	35,888	384	14		
18	Benavides (North Sweden), *Duval*	1937	3,900	14,061,643	1,396,333	279	1	
19	Benavides, East, *Duval*	1941	100	40,346	19,825	2	0	
20	Ben Bolt, *Jim Wells*	1939	2,100	3,546,701	856,831	81	0	
21	Bird Island, *Kleberg*	1938	40	41,364	2,216	3	0	
22	Blanchard, *Duval*	1939	60	52,500	1,333	4	0	
23	Blanconia, *Bee*	1943	300	42,768	41,047	17	11	4
24	Blutcher, *Jim Wells*	1939		9,795	6,774	*x*	0	*x*
25	Boedecker, *Brooks*	1944				2	2	
26	Boyle, *Starr*	1940	300	452,268	159,955	19	2	?
27	Brayton, *Nueces*	1944		32,879	32,879	4	4	0
28	Bridwell, *Duval*	1940	320	248,958	99,777	13	0	0
29	Brownlee, *Jim Wells*	1944		7,632	7,632	2	2	
30	Brushy Creek, *Lavaca*	1941	80	33,973	28,352	*x*	*x*	*x*
31	Burnell, South, *Karnes*	1937	320	1,126,781	53,238	26	1	?
32	Cabeza Creek, South, *Goliad*	1944				1	1	
33	Cadena, *Duval*	1942	320	227,117	157,960	17	5	
34	Canales, *Bee, Jim Wells*	1944		156,689	156,689	4		
35	Caesar, *Bee*	1934	500	1,068,143	113,845	42	0	*x*
36	Caesar, South, *Bee*	1942	1,000	1,095,101	645,928	21	9	0
37	Calliham, *McMullen*	1918	890	1,011,216	31,097	142	0	*x*
38	Cameron, *Starr*	1943	100	182,893	164,007	14	12	2
39	Campana, South, *McMullen*	1941	180	194,760	70,475	15	1	*x*
40	Captain Lucy, *Jim Wells*	1932	220	567,521	27,785	23	0	*x*
41	Casa Blanca, *Duval*	1938	550	1,034,680	236,044	59	1	
42	Casa Blanca, North, *Duval*	1939	100	184,642	37,964	9	0	
43	Casa Blanca, West, *Duval*	1941	160	249,476	114,106	20	0	
44	Cedro Hill, *Duval*	1938	770	1,288,863	347,152	81	0	
45	Chapa, *Live Oak*	1944						
46	Chapman Ranch, *Nueces*	1937	100	107,119	25,169	6	1	
47	Charamousa, *Duval*	1935	410	978,755	106,479	41	0	
48	Chareo Redondo, *Zapata*	1913	140	162,544	378	?	1	
49	Charlotte, *Atascosa*	1944		12,537	12,537	3	3	0
50	Chiltipin, *Duval*	1939	60	55,888	3,347	6		
51	Clara Driscoll, *Nueces*	1935	300	1,596,230	153,210	30	0	
52	Clara Driscoll, South, *Nueces*	1937	2,000	5,015,524	794,220	99	0	
53	Colleto Creek, *Victoria*	1934	460	1,832,004	175,133	50	0	
54	Colmena, *Duval*	1934	240	619,678	47,555	36		
55	Coloma Creek, *Calhoun*	1941	80	54,152	2,163	2		
56	Colorado, *Jim Hogg*	1936	3,600	3,680,051	807,682	245	1	
57	Comitas, *Zapata*	1934	750	1,865,845	96,933	196	0	
58	Conoco Driscoll, *Duval*	1924	3,580	6,879,551	1,070,982	119	2	
59	Coquat, *Live Oak*	1944		3,256	3,256			
60	Cordelle, *Jackson*	1938	620	2,995,795	363,287	50	0	
61	Cortez, *Starr*	1944				1	1	
62	Corpus Christi, *Nueces*	1935	160	6,762,482	3,250	252		
63	Cosden, *Wilcox*	1944				1	1	
64	Cottonwood Creek, *De Witt*	1944				1	1	
65	Cuellar, *Zapata*	1927	540	2,657,234	9,451	86	0	
66	Dan Sullivan, *Brooks*	1944		7,080	7,080	1	1	

[a] Footnotes to column heads and explanation of symbols are given on page 258.

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil, Flowing	Oil, Artificial Lift	Gas	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
1	0	64	0		20.8	Mirando, Eoc	S	P	975	7	ML	Yegua	1,517
2	124	11			40–60	Frio, Olig	S	25	4,650	75	AF	Yegua	13,728
3	2		1		46	Pettus, Eoc	S	P	4,708	7	NF	Yegua	5,025
4	0	8	0		21	Cole, Eoc	Sd	P	2,125	17	MFL	Yegua	3,700
5	1				53.8	Wilcox	S		8,350				10,958
6					41–46	Frio, Vicksburg	S	P			AF		
7	13	7	2		41–46	Frio, M Olig, Vicksburg, Olig	S	P	3,225	20	AF	Yegua	6,535
8	26	22	19		46	Frio, M Olig	S	30–35	3,225	14	NFh	Yegua	6,535
9	35	0	18		42	Frio, M Olig	S	P	3,480	55	ANh	Vicksburg	5,760
10	2	31			24	Catahoula, M Olig	S	P	2,400	8	DS	Yegua	8,822
11	35	138	48		42.9	Frio, Olig	S	25–34	6,500	9	AF	Frio	10,468
12					gas	Het, Olig	S	P			D		
13			1		gas		S		5,355			Frio	6,335
14	13	1	1		37		S	P	3,240		*x*	*x*	3,668
15	74		?		21	Mirando, Eoc	S	P	1,525	11	MFh	Cook Mt.	3,975
16	1	18	1		25.9	Catahoula, Olig	S	P	2,900	8	AF	Frio	6,610
17		1	?		24.9	Frio, Olig	S	P	2,450	15	AF	Yegua	6,567
18	75	125	15		43	Cole, Eoc	S	27	3,840	19	AFL	Yegua	6,510
19	1		?		43	Eoc	S	P	4,915	10	AF	Yegua	6,510
20	44	20	?		36–43	Frio, Olig	S	P	4,500	14	ANh	Yegua	6,140
21	1		2		44	Frio, Olig	S	P	7,205	8	AF	Frio	9,636
22	2		1		43	Pettus, Eoc	S	P	4,683	8	MF	Yegua	5,807
23	7	0	6		25	Frio, Olig	S	P	4,959	6	FS	Frio	5,198
24	*x*	*x*	*x*		58	Frio, Vicksburg	S	P	7,500	20	*x*	Vicksburg	8,004
25					63.5	Frio	S		6,165				7,233
26	14	1	?		44	Frio, Olig	S	P	3,490	10	AF	Yegua	4,520
27	2		2			Frio	S		7,200				7,419
28	11	1			43.5	Pettus, Eoc	S	P	4,292	8	MF	Yegua	4,657
29	1		1										
30	*x*	*x*	*x*		54–57	Wilcox	S	low	7,680	30	*x*	Wilcox	10,998
31	3	23			45	Pettus	S	fair	3,650	7	F	*x*	*x*
32					53	Wilcox	S		8,210				9,018
33	9	1	?		40	Pettus, Eoc	S	P	5,269	6	AF	Yegua	5,860
34	4				39.9	Frio	S		7,235				7,239
35	16				24.7	Cockfield, Eoc	S	P	3,070	15	DF	Yegua	4,230
36		29			42.2	Wilcox, Eoc	S	P	6,504	20	DF	Wilcox	7,507
37	0	59	0		20	Carrizo, Eoc	S	P	848	15	MFL	Carrizo	5,301
38	12				45.9	*x*	S	P	4,140	*x*	*x*	*x*	*x*
39	14	0	0		22.8	Pettus, Eoc	S	P	1,864	8	MF	Cook Mt.	4,486
40	2	4	?		47	Frio, Olig	S	P	5,679	11	AF	Yegua	6,500
41		51			21	Cole, Eoc	S	P	1,180	8	ML	Yegua	2,133
42	0	9	0		21	Cole, Eoc	S	P	1,030	10	ML	Yegua	1,788
43		15			21	Cole, Eoc	S	P	994	8	ML	Yegua	2,212
44	5	73			20	Cole, Eoc	S	P	1,436	10	MFL	Yegua	2,646
45									8,150			Wilcox	8,547
46	4	2			27.9	Catahoula, Olig	S	P	3,900	10	AF	Frio	7,750
47	1	16			20	Cole, Eoc	S	P	1,525	10	MFL	Cook Mt.	3,892
48	28	0	1		17	Jackson	S	low	200	5	L	*x*	*x*
49	2	0	1		37.7	Edwards			6,920				6,923
50	5				49.6	Pettus, Eoc	S	P	4,760	10	NF	Yegua	5,410
51	5	13	?		23–37	Frio, Olig	S	P	5,320	15	A	Frio	8,055
52	45	50			23–40	Catahoula, Olig	S	P	3,800	10	A	Frio	7,560
53	24	7			21	Frio, Olig	S	P	2,776	10	DF	Yegua	7,860
54	22				21	Cole, Eoc	S	P	1,486	8	ML	Yegua	3,396
55	1				53.7	Mirando, Mio	S	P	5,880	10	DF	Olig	8,514
56	194	45			47.2	Cockfield, Eoc	S	P	2,820	10	ML	Cook Mt.	4,510
57		142			20.6	McElroy, Eoc	S	P	800	10	ML	Cook Mt.	3,502
58	52	10			30	Frio, Olig	S	P	2,300	13	NL	Cook Mt.	5,390
59													
60	29	16	0		22	Miocene, Mio	S	P	2,566	15	DF	Vicksburg	5,117
61									2,830			Frio	4,620
62					25	Miocene	S	P	3,974	10	A	Frio	7,531
63													
64									7,630			Frio	9,017
65	11		1		20.9	McElroy, Eoc	S	P	1,525	10	ML	Mt. Selman	4,532
66		1							8,512			Frio	8,522

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[e] To End of 1944	Oil Production: Total Production, Bbl.[e] During of 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
67	Daugherty, *Nueces*	1944		4,129	4,129	2	2	
68	Diamond Half, *Goliad*	1936	240	656,447	16,845	22	0	
69	Dirks, *Bee*	1934	865	6,674,142	386,821	101	0	
70	Eagle Hill, *Duval*	1933	550	2,082,751	197,191	61	0	
71	East, *Jim Hogg*	1942	400	94,111	57,027	12	3	0
72	Escobas-Jennings	1914	3,700	11,531,738	516,403	539	0	
73	Ezzell, *McMullen, Live Oak*	1937	1,450	3,204,028	230,669	151	0	
74	Fagan, *Refugio*	1940	300	90,914	15,836	9	0	
75	Fitzsimmons, *Duval*	1938	900	3,170,115	310,098	79	0	
76	Flour Bluff, *Nueces*	1936	2,280	9,078,692	1,031,732	117	0	
77	Flour Bluff, East, *Nueces*	1940	1,200	1,067,651	445,157	23	0	
78	Francitas, *Jackson*	1938	1,500	581,677	170,432	16	0	
79	Frost, *Starr*	1942	80	6,683	1,412	2	0	
80	Gallagher, *Jim Wells*	1940	160	182,185	57,995	5	1	0
81	Ganado, *Jackson*	1937	2,400	1,469,702	506,700	?	?	
82	Ganado, West, *Jackson*	1940	1,200	1,480,226	616,488	?	?	
83	Garcia, *Starr*	1942	160	301,934	224,867	27	23	4
84	Glenn, *Webb, Zapata*	1940	710	1,672,727	491,329	75	0	
85	Goebel, *Live Oak*	1943	100	32,201	22,024	2	1	0
86	Government Wells, *Duval*	1928	8,500	54,589,128	2,550,056	836		
87	Green, *Karnes*	1944		10,375	10,375	1	1	0
88	Green Branch	1944		22,289	22,289		2	
89	Gregory, *Live Oak*	1944		7,010	7,010	2	2	
90	Greta, *Refugio*	1933	4,400	33,583,235	3,129,654	251	4	
91	Guerra, *Starr*	1933	400	1,653,057	228,984	21		
92	Haldeman, *Jim Wells*	1941	60	45,566	14,201	2	0	0
93	Harmon, *Jackson*	1942	600	465,991	165,905	17	3	0
94	Herbst, *Duval*	1944		1,360	1,360	1	1	0
95	Henshaw, *Jim Wells*	1940	50	76,339	18,883	4	0	
96	Heyser, *Calhoun, Victoria*	1936	5,500	23,828,052	3,331,821	277	0	
97	Hobson, *Karnes*	1943	300	378,949	249,599	12	1	1
98	Hoffman, *Duval*	1933	3,400	11,953,945	1,545,881	385	0	
99	Holbein, *Jim Hogg*	1940	100	132,350	25,667	10	0	0
100	Holzmark, *Bee*	1935	50	150,833	80,893	6	1	0
101	Hondo Creek, *Karnes*	1943	50	65,880	34,238	4	3	
102	Hordes Creek, *Goliad*	1940	100	81,537	4,728	7	0	
103	Jacob, *McMullen*	1926	1,230	1,810,119	78,074	129	0	
104	Keeran, *Victoria*	1932	1,350	2,095,390	256,700	21	0	
105	Kelsey, *Jim Hogg, Starr, Brooks*	1938	2,300	3,426,593	880,551	120	0	
106	Little Kentucky, *Jackson*	1943	50	44,351	41,696	4?	3	0
107	Killam, *Webb*	1937	950	1,370,536	121,769	133	0	
108	Killam, North, *Webb*	1938	80	80,379	4,263	7	0	
109	Kingsville, *Kleberg*	1920	240	785,116	19,903	20	0	
110	Kohler, *Duval*	1926	360	703,539	11,489	95	0	
111	Koontz, *Victoria*	1944		3,480	3,480	3	3	
112	Koopman, *Jim Wells*	1942	80	32,220	7,054	3	0	
113	Kreis, *Duval*	1940	200	171,123	42,127	9	0	
114	Labbe, *Duval*	1934	230	518,331		31	0	
115	La Blanca?	1936	4,000			7	0	0
116	La Gloria, *Jim Wells, Brooks*	1939	4,500	86,822	10,801	44	1	
117	La Rosa, *Refugio*	1938	1,720	5,989,131	1,635,887	96	0	
118	La Rosa, North, *Refugio*	1943		31,156	28,495	2	1	
119	Las Animas, *Jim Hogg*	1937	100	84,959	13,156	11	0	
120	Las Mujeris, *Jim Hogg*	1944		813	813	1	1	
121	Laurel, *Webb*	1932	220	631,075	2,529	33	0	
122	La Ward, North, *Jackson?*	1941	4,000	2,248,208	929,048	96	27	?
123	Lockhart, *Starr*	1943	500	211,805	139,188	11	0	
124	Lolita, *Jackson?*	1940	3,100	7,977,899	2,142,561	176	0	0
125	Loma Alta, *McMullen*	1935	80	193,578	15,301	4	0	
126	Loma Alta-Wilcox, *McMullen*	1944		4,048	4,048	1	1	0
127	Loma Novia, *Duval*	1934	7,410	29,759,959	1,390,739	758	0	
128	Loma Vista, *Duval*	1936	10	19,661	1,075	2	0	

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
67		1	1						5,550			Frio	6,520
68		7			40	Cockfield, Eoc	S	P	3,660	14	DF	Yegua	4,540
69		85			44	Cockfield, Eoc	S	P	3,819	16	DF	Yegua	4,776
70		51			19–22	Cole, Eoc, Govt. Wells, Eoc	S	P	1,450	10	MFL	Yegua	2,752
71	12				51	Cockfield, Eoc	S	P	4,741	10	A	Yegua	5,303
72		305			20	Yegua, Eoc	S	P	900	12	MFh	Mt. Selman	4,645
73		126			20	Loma Nova, Eoc	S	P	1,490	8	ML	Cook Mt.	3,168
74	4				28.6	Miocene, Mio, Frio, Olig	S	P	2,118	10	DF	Olig	7,200
75	49	25			46	McElroy, Pettus, Eoc	S	P	3,592	10	MF	Yegua	5,285
76	55	23			43	Marginulina, L Olig	S	P	6,590	25	AF	Frio	7,504
77	20				41.6	Marg., L. Olg	S	P	6,753	8	AF	Frio	8,694
78	13				50	Frio, Olig	S	P	7,378	15	D	Vicksburg	10,665
79	2				45	Frio, Olig	S	P	4,181	8	ML	Vicksburg	5,435
80	5	0	0		39	Frio, Vicksburg, Olig	S	P	5,189	*x*	NFL	Yegua	6,260
81	50	1	0		25.6–35.1	Marg., Frio, Olig	S	P	5,080	15	DF	Frio	7,635
82	30	0	0		24.1	Frio, Olig	S	P	4,760	10	DF	Vicksburg	7,635
83	23	0	0		42	Frio, Olig	S	P	3,740	6	AF	Frio	4,075
84	18	49			22	Mirando, Eoc	S	P	2,160	12	NL	Yegua	3,240
85	2	0	0		38	Wilcox, Eoc	S	P	7,054	10	*x*	Wilcox	7,095
86	8	233			21	Cole, Het., Govt. Wells, Mirando, Yegua, Eoc	S	P	1,550	17	NFL	Mt. Selman	5,858
87	1	0	0		36.7								
88													
89	1	1											
90	145	50			23.5–39.3	Miocene, Mis, Het., Mio, Frio, Olig	S	20–33	3,500	15	A	Vicksburg	7,473
91	8	7			33	Cole, McElroy, Eoc	S	P	1,745	14	MF	Yegua	3,600
92	1	1			33	Frio, Olig	S	P	5,019	11	NF	Yegua	6,498
93	7	10			28.8	Frio, Olig	S	P	5,320	10	T	Frio	6,717
94	0	1	0										
95	1	1			31	Frio, Vicksburg, Olig	S	P	3,778	11	NF	Vicksburg	5,885
96	179	46			31–43	Miocene, Mio, Frio, Olig	S	P	5,400	25	A	Frio	6,487
97	11				32	Wilcox, Eoc	S	25–30	4,000	20	AF	Basal Wilcox	7,474
98	2	305			22–25	Hockley, Govt. Wells, Loma Novia, Cockfield, Eoc	S	P	2,550	17	AF	Yegua	3,800
99	0	10	0		24.5	Pettus, Eoc	S	P	2,793	10	NL	Yegua	3,150
100	5	1	0		31.9–48.8	Hockley, Yegua, Eoc	S	P	3,500	5	DF	Cockfield	4,458
101	2				48.8	Wilcox, Eoc	S	P	6,580	15	*x*	Wilcox	6,580
102	1				43.1	Yegua, Eoc	S	P	4,545	10	DF	Cook Mt.	6,004
103		68			21	Mirando, Pettus, Yegua, Eoc	S	P	780	8	ML	Mt. Selma	3,171
104	12	6			26–40	Frio, Olig	S	15	4,800	10	A	Vicksburg	10,043
105	70	6			44	Frio, Olig, Govt. Wells, Eoc., Yegua, Eoc	S	P	4,671	13	A	Yegua	7,507
106	4	0	0		35.4	Frio, Olig	S	P	5,700	10	*x*	Frio	5,700
107		4			21	Mirando, Cockfield, Eoc	S	P	1,920	13	ML	Yegua	3,011
108		4			22	Mirando, Cockfield, Eoc	S	P	2,046	15	ML	Yegua	3,060
109	2	1			21	Miocene, Mio, Catahoula, Olig	S	P	1,400	20	D	Frio	6,922
110		7			22	Cole, Govt. Wells, Mirando, Eoc	S	P	1,748	14	ML	Carrizo	7,723
111	2		1		25								
112		1			44.5	Frio	S	P	4,112	10	ML	Vicksburg	6,016
113		10			31	Mirando, Eoc	S	P	3,200	12	NL	Yegua	4,732
114		9			25	Cole, Chemosky, Loma Nova, Eoc	S	P	1,872	12	ML	Yegua	4,054
115	0	0	7		55	Frio	S	tight	7,500	40	A	Frio	8,890
116	1	1	?		39–55	Frio, Vicksburg, Olig	S	P	5,888	19	A	Yegua	8,043
117	78	4			29.8–39.4	Frio, Olig	S	P	5,400	12	DF	Vicksburg	8,020
118	2				50	Frio, Olig	S	P	6,180	10	*x*	*x*	*x*
119		8			18.5	Cole, Eoc	S	P	1,782	22	NL	Yegua	4,014
120	1												
121		3			49	Frio, Mirando, Cockfield, Eoc	S	P	360	6	MFL	Cook Mt.	3,165
122	96	0	0		26	Marg., Frio, Olig	S	P	5,200	7	DF	Vicksburg	7,735
123	9	1			46.6	Cockfield, Yegua	S	P	3,600	8	*x*	Yegua	4,600
124	176	0	0		26–33	Marg., Frio, Olig	S	P	5,200	9	D	Frio	7,280
125		3			21	Chemosky, Eoc	S	P	2,195	12	MFL	Cockfield	2,766
126	1	0	0										
127		518			23	Loma Novia, Mirando, Eoc	S	P	2,550	20	ML	Cook Mt.	4,200
128	1				25.7	Loma Novia, Eoc	S	P	2,914	7	ML	Cook Mt.	4,732

TABLE I.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned
129	London, *Nueces*	1937	80	128,903	16,746	4	0	
130	Longhorn, *Duval*	1938	1,000	2,579,426	357,283	52	3	
131	Lopena, *Zapata*	1934	1,100	gas				
132	Lopez, *Webb, Duval*	1935	3,450	14,286,088	880,803	369	0	
133	Los Olmos, *Starr*	1925	240	663,777	6,876	110	0	
134	Luby, *Nueces*	1937	3,000	10,419,822	1,544,823	154	1	
135	Luby, North, *Nueces*	1939	80	151,586	27,367	5	0	
136	Mt. Lucas, *Live Oak*	1923	120	356,293	12,554	32	0	
137	Lundell, *Duval*	1937	940	2,148,182	375,748	104	0	
138	Lykes, *Webb*	1942	20	2,057	428	1	0	
139	Magnolia City, *Jim Wells*	1939	120	299,838	97,345	14	5	
140	Magnolia City, North, *Jim Wells*	1943	200	209,512	177,540	6	2	
141	Manila, *Jim Hogg*	1940	230	315,808	44,830	26	0	
142	Martinez (incl. South Martinez), *Zapata*	1929		gas				
143	Mathis, East, *San Patricio*	1924	300			2	0	0
144	Maubro, *Jackson'*	1941	3,275	1,758,996	646,419	71	*x*	0
145	Mauritz, *Jackson*	1935	200	862,907	180,416	8	0	0
146	Mauritz, West, *Jackson*	1942	500	577,158	305,350	13	6	0
147	Mayo, *Jackson*	1942	1,600	987,251	557,976	32	11	*x*
148	McAllen, Pharr, *Hidalgo?*	1938	960			4	0	0
149	McFaddin, *Victoria*	1930	1,000	7,473,429	2,035,618	94	1	
150	McFaddin, North, *Victoria?*	1937	100			24	2	
151	McLean, *Webb*	1942	200			5	0	0
152	McNeil, *Live Oak*	1934	180	297,796	10,044	7	0	
153	Melon Creek, *Refugio*	1939	210	930,122	178,340	10	0	
154	Mercedes, *Hidalgo*	1935	560			7	0	0
155	Midway, *San Patricio*	1937	1,860	4,076,856	1,191,045	74	1	
156	Mirando City, *Webb*	1921	1,430	9,475,603	82,504	295	0	
157	Mirando Valley, *Zapata*	1921	1,000	1,582,081	20,223	146	0	
158	Mission River, *Refugio*	1938	381	2,075,779	203,138	18	1	
159	Moca, *Webb*	1932	100	1,292,341	49,051	12	0	
160	Munson, *McMullen*	1938	150	210,343	12,933	17	0	
161	Neuhaus, *Jim Hogg*	1941	80	46,438	24,242	7	5	
162	Nichols, *Hidalgo*	1940	280	401,098	104,260	15	0	
163	Normanna, *Bee*	1930	70	108,228	6,412	7	0	
164	Oakville, *Live Oak*	1937	400	1,157,756	128,550	48	2	
165	Odem, *San Patricio*	1939	2,200	1,828,860	770,553	65	5	
166	Odem, North, *San Patricio*	1944		2,542	2,542	1	1	0
167	Oiton, *Webb*	1937	525	1,773,721	49,683	141	0	
168	Orange Grove, *Jim Wells*	1940	1,040	2,118,881	488,768	40	0	
169	Penitas	1942						
170	Peters, *Duval*	1933	300	279,738	19,803	21	0	
171	Peters, East, *Duval*	1940	60	43,518	9,634	4	0	
172	Petronilla, *Nueces*	1941	1,000	240,475	140,203	13	5	
173	Pettus, Old	1929	1,200			91	1	0
174	Piedre Lumbre	1935	1,300			144	0	*x*
175	Placedo, *Victoria*	1935	3,000	16,881,414	1,771,582	185	3	
176	Placedo, East, *Victoria*	1937	600	1,303,317	469,610	32	0	
177	Plummer, *Bee*	1937	160	277,425	1,523	15	0	
178	Plymouth, *San Patricio*	1935	3,750	32,689,347	3,518,593	204	3	
179	Porter, *Karnes*	1943	400	309,752	231,509	13	0	
180	Premont, *Jim Wells*	1933	720			63	0	
181	Pridhams Lake, *Victoria*	1944		16,985	16,985	3	3	1
182	Quinto Creek, *Jim Wells*	1942	80	78,849	30,487	4	0	
183	Rancho Solo, *Duval*	1935	440	303,837	38,780	45	0	
184	Randado, *Jim Hogg*	1926	765	5,000,057	54,166	191	0	
185	Ray, *Bee*	1935	420	1,676,833	61,568	42	2	
186	Refugio, *Refugio*	1922	8,500	43,125,660	1,655,092	500	0	
187	Refugio-Top, *Refugio*	1931	850	4,550,476	235,233	17	0	
188	Reynolds, *Jim Wells*	1939	690	1,529,643	153,720	32	0	
189	Ricaby, *Starr*	1937	150	179,348	28,276	14	0	
190	Richard King (East Bentonville), *Nueces*	1937	2,000	4,099,064	1,201,813	100	18	
191	Rincon, *Starr*	1938	4,500	8,650,103	2,710,086	162	0	
192	Rincon, North, *Starr*	1940	400	423,290	214,267	25	10	
193	Rio Grande City, *Starr*	1932	200	473,657	26,118	34	0	

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil, Flowing	Wells Producing[g] Dec. 1944: Oil, Artificial Lift	Wells Producing[g] Dec. 1944: Gas	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
129		3			24.4	Catahoula, Olig	S	P	4,698	8	NF	Frio	7,424
130	31	14			45	Cole, Govt. Wells, Eoc	S	P	4,009	10	AFL	Yegua	6,011
131													
132		299			20.7	Mirando, Eoc	S	P	2,126	18	ML	Yegua	3,437
133		75			20	Frio, Olig	S	P	250	17	ML	Yegua	2,612
134	133	12			45.7	Catahoula, Het., Frio, Olig	S	30	4,300	15	AF	Frio	7,595
135		3			48	Catahoula, Het., Olig	S	P	4,300	10	AF	Frio	7,300
136		3			23	Frio, Olig, Yegua, Eoc	S	P	2,510	20	D	Cook Mt.	6,789
137	26	67			19	Cole, Eoc	S	P	1,500	10	MFL	Yegua	2,698
138		1			45	Mirando, Eoc	S	P	1,950	14	ML	Yegua	2,638
139	5				42	Frio, Olig	S	P	5,436	9	A	Yegua	6,592
140	7		1		34.8	Frio	S	P	3,628	10	x	Vicksburg	6,015
141	1	12			24.9	Pettus, Eoc	S	P	2,541	10	NL	Yegua	3,006
142													
143	0	0	2		35	Frio, Vicksburg, Olig	S	P	4,400	9	NF	Yegua	6,348
144	66	9			24.4	Frio, Olig	S	P	5,220	10	D	Frio	6,520
145	9	2			31.4	Frio, Olig	S	P	5,650	10	D	Vicksburg	7,808
146	17				33.8	Frio, Olig	S	P	5,470	10	DF	Frio	6,760
147	33	3			29	Frio, Olig	S	P	5,100	10	DF	Vicksburg	7,808
148	0	0	4		60	Frio, Olig	S	P	5,970	23	AF	Vicksburg	8,575
149	58	30			21–40	Het., Frio, Olig	S	P	4,400	15	AF	Frio	7,025
150	4	1			38–47	Frio, Olig	S	P	5,350	10	A	Frio	7,506
151	0	5	0		55	Yegua, Eoc	S	P	3,238	15	NL	Cook Mt.	4,016
152	5				44.3	Hockley, Jackson	S	P	4,434	10	D	Cook Mt.	6,212
153	10				35.4	Frio, Olig	S	P	5,856	20	D	Frio	5,876
154	0	0	7		49	Frio, Olig	S	P	7,430	15	DF	Vicksburg	9,618
155	44	24			38	Het., Frio, Olig	S	P	5,285	19	AF	Vicksburg	10,004
156		59			20	McElroy, Cockfield, Eoc	S	P	1,530	10	ML	Mt. Selman	5,000
157		40			20	McElroy, Mirando, Eoc	S	P	1,400	9	ML	Cook Mt.	3,660
158	9	8			31.2–41	Frio, Olig	S	P	5,183	10	D	Vicksburg	9,225
159		11			21	Mirando, Eoc	S	P	900	10	MFL	Yegua	2,178
160		11			22	Mirando, Eoc	S	P	1,200	12	ML	Pettus	1,501
161	2	3			47	Pettus, Eoc	S	P	3,454	9	MF	Pettus	3,471
162	6	6			34	Frio, Olig	S	30	3,132	8	AF	Yegua	5,482
163	1	2			37.7	Yegua, Eoc	S	P	3,500	17	D	Yegua	5,038
164	2	20			20–24	{Miocene, Mio, Yegua, Olig, Cockfield, Eoc}	S	P	1,830	8	AF	Cook Mt.	4,500
165	60	1			35	Catahoula, Het., Frio, Olig	S	30	3,500	24	AF	Frio	7,517
166	0	1	0		22								
167		49			32	Mirando, Cockfield, Eoc	S	P	1,880	13	ML	Yegua	3,151
168	23	7			32	Frio, Olig	S	P	3,292	15	NF	Yegua	6,012
169	1	3			23								
170	1	3			22.9	Cole, Govt. Wells, Mirando, Eoc	S	P	1,750	13	ML	Cook Mt.	4,004
171	1	3			22.9	Govt. Wells, Eoc.	S	P	2,441	13	ML	Mirando	2,563
172	11				40	Frio, Olig	S	P	6,952	9	NF	Frio	10,020
173	0	29	0		44.7	Cockfield, Eoc	S	P	3,900	19	DF	Wilcox	8,993
174	9	121	0		22	Cole, Govt. Wells, Loma Novia, Eoc	S	P	1,324	10	ML	Midway	10,931
175	48	107	1		22–29	Het., Frio, Olig	S	P	4,700	15	AF	Frio	7,242
176	28	3			38	Frio, Olig	S	P	6,000	10	AF	Frio	7,502
177		2			30	Cockfield, Eoc	S	P	3,050	5	DF	Cook Mt.	4,756
178	163	24			31	Frio, Olig	S	P	5,458	10	AF	Frio	7,253
179	12	1			48	Pettus, Eoc	S	P	3,950	10	AF	Wilcox	8,015
180	1	1			23	Catahoula, Frio, Olig	S	P	2,250	10	D	McElroy	7,155
181	1	1											
182	1				29	Frio, Vicksburg, Olig	S	P	4,860	13	NF	Yegua	5,900
183		20			19	Cole, Govt. Wells, Eoc	S	P	1,800	10	ML	Yegua	3,777
184		81			19	Cole, Eoc	S	P	1,220	10	NL	Mt. Selman	5,222
185		10			46	Cockfield, Eoc	S	P	3,920	15	DF	Yegua	4,253
186	85	51			23–40	Catahoula, Frio, Olig	S	30	3,700	15	DF	Vicksburg	9,373
187	14	5			33.9	Marg., Olig	S	34	5,890	10	D	Frio	7,300
188	14	7			35	Frio, Olig	S	P	3,145	10	ANL	Yegua	6,025
189		9			21	Frio, Olig	S	P	1,270	7	NL	Yegua	2,844
190	85	9			22–56	Frio, Vicksburg, Olig	S	P	3,800	10	AF	Yegua	7,576
191	142	5			40	Frio, Vicksburg, Olig	S	26–39	3,629	19	A	Yegua	6,862
192	14	5			42	Frio, Vicksburg, Yegua, Olig	S	P	4,111	14	A	Yegua	5,590
193		9			29	Frio, Olig	S	P	1,350	8	MFL	Yegua	3,258

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned
194	Rios, *Duval*	1941		gas		1	0	
195	Riverside, *Nueces*	1938	2,000	186,382	49,326	8	1	
196	Robinson, *Duval*	1944		932	932	1	1	0
197	Robstown, *Nueces*	1939	200	159,646	49,227	8	1	
198	Rooke, *San Patricio*	1942	200	218,659	?	13	8	
199	Rosita, *Duval*	1944		45,347	45,347	3	3	0
200	Ross, *Starr*	1943	640	199,759	194,381	27	23	
201	Sam Fordyce, *Hidalgo, Starr*	1934	1,600	7,670,835	82,063	259	0	
202	Sandia, *Jim Wells*	1929		gas		9	0	
203	San Salvador, *Hidalgo*	1938		gas		8	1	
204	Sarnosa, *Duval*	1932	690	2,874,409	95,201	57	0	
205	Saxet (Deep, Frio), *Nueces*	1935	2,450	26,660,757	1,152,214	762	1	
206	Saxet (Shallow), *Nueces*	1923	3,850	32,088,553	1,358,698			
207	Scott and Hopper, *Brooks*	1944		86,248	86,248	4	4	
208	Seeligson, *Jim Wells, Kleberg*	1937	9,300	9,689,855	7,440,558	185	90	
209	Sejita, *Duval*	1939	4,000	566,433	425,856	36	14	
210	Seven Sisters, *Duval*	1934	4,420	21,940,621	2,392,569	461	3	
211	Seven Sisters, South, *Duval*	1937	330	763,350	30,645	33	0	
212	Shield, *Nueces*	1940	2,100	579,121	141,960	15	0	
213	Sinton, *San Patricio*	1934	300	71,240	0	11	3	
214	Slick-Wilcox, *Goliad*	1943	1,000	906,123	843,974	40	33	
215	Southland, *Duval*	1939	350	230,692	59,601	8	3	
216	Stewart, *Jackson*	1942	350	199,350	101,774	7	1	0
217	Strake, *Duval*	1943	120	132,567	79,596	3	0	
218	Stratton, *Nueces, Kleberg, Jim Wells*	1931	13,500	7,253,433	4,077,580	252	44	
219	Sullivan City, *Hidalgo, Starr*	1939	780	799,635	194,827	39	0	
220	Sun, *Starr*	1938	2,400	3,161,181	1,197,084	88	0	
221	Sun, North, *Starr*	1941	1,000	825,160	563,086	31	5	
222	Sun-Jones, *Jim Hogg*	1941		gas		4	0	
223	Sweden, *Duval*	1937	1,500	285,218	17,222	15	0	
224	Taft, *San Patricio*	1935	720	6,919,192	1,102,038	81	7	
225	Tarancahua, *Duval*	1939	290	788,717	177,753	29	0	
226	Telferner, *Victoria*	1938	30	72,024	4,978	6	2	
227	Tesoro, *Duval*	1938	140	234,697	14,121	8	0	
228	Texanna, *Jackson*	1939	300	41,435	5,624			
229	Tijerina, *Jim Wells*	1944		91,008	91,008	9	9	
230	Tom O'Connor, *Refugio*	1934	12,000	65,427,260	18,743,700	451	0	
231	Tuleta, *Bee*	1932	1,160	1,992,105	30,483	77	2	
232	Tulsita, *Bee*	1938	120	13,428	1,812	12	0	
233	Turkey Creek, *Nueces*	1938	12,000	5,428,198	481,697	60	0	
234	Tynan, *Bee*	1942	40	10,908	5,873	1	0	
235	Victoria, *Victoria*	1940	300	422,191	55,013	26	0	
236	Volpe, *Webb*	1939	330	756,498	156,864	34	0	
237	Wade City, *Jim Wells*	1939	2,000	4,790,589	924,492	107	0	
238	Warmley, *De Witt*	1944		2,044	2,044	1	0	0
239	Weesatche, *Goliad*	1944		629	629	2	2	0
240	Weil, *Jim Hogg*	1943	240	85,352	74,530	7	1	0
241	Welder, *Duval*	1944		8,030	8,030	2	2	0
242	Weser, *Goliad*	1936	140	34,903	34,903	10	0	
243	West Ranch, *Jackson*	1938	10,000	26,012,707	8,130,539	390	13	0
244	White Creek, *Live Oak*	1939	400	449,145	45,352	35	0	
245	White Creek, South, *Live Oak*	1941	100	182,922	34,404	7	0	
246	White Point, *San Patricio*	1911	2,100	223,968	21,135	48	0	
247	White Point, East, *San Patricio*	1938	4,800	19,583,029	4,507,011	251	0	
248	Willamar, *Willacy*	1940	6,000	1,457,856	1,267,949	19	58	
249	Woodsboro, *Refugio*	1941	300	288,407	151,365	8	1	
250	Yeager, *Jim Hogg*	1943	200	75,836	48,543	7	3	
251	Young, *Starr*	1938		gas				
252	Yturria, *Starr*	1941	760	315,652	113,764	18	5	
253	Yzaguirre, *Starr*	1940	40	5,042	159	4	2	

TABLE 1.—(*Continued*)

Line Number	Wells Producing[g] Dec. 1944: Oil: Flowing	Oil: Artificial Lift	Gas	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Producing Formation: Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Depth of Hole, Ft.
194													
195	4				32	Frio, Olig	S	30	5,000	15	A	Frio	7,750
196	1	0	0										
197	4				41–51.9	Frio, Olig	S	*x*	5,195	11	A	Frio	7,525
198	12				39.1	Frio, Olig	S	P	7,135	15	*x*	Frio	7,165
199	3	0	0										
200	12	10	1		26	*x*	S	P	2,520	*x*	*x*	*x*	*x*
201	2	42			24	Frio, Olig	S	P	2,737	16	AF	Mt. Selman	9,708
202		2											
203													
204		34			21.3	Govt. Wells, Eoc	S	P	2,300	15	MFL	Yegua	4,073
205	20	57			30–40	Frio, Olig	S	*x*	5,200	10	DF	Vicksburg	10,892
206	22	178			24–31	Catahoula, Het., Olig	S	30	3,900	18	DF	Vicksburg	10,892
207	4												
208	319?	3			36–50	Frio, Olig	S	P	4,900	20	A	Vicksburg	8,162
209	23	2			44	McElroy, Eoc	S	P	5,334	17	AF	Yegua	7,095
210	2	385	2		23	Frio, Olig	S	P	1,232	23	AFL	Yegua	4,404
211		23			22	Frio, Olig, Loma Novia, Eoc	S	P	1,487	9	AFL	Yegua	3,100
212	6	4			44.3	Frio, Olig	S	P	6,600	12	AF	Frio	7,806
213	0	0	3		53	Frio, Olig	S	P	3,260	22	A	Frio	7,438
214	35				36.4	Wilcox, Eoc	S	P	7,560	50	DF	Wilcox	7,560
215	5				43.8	Pettus, Eoc	S	P	5,298	10	AFL	Yegua	6,015
216	7	1			26.1	Frio, Olig	S	P	4,950	10	DF	Olig	7,508
217	2	1			23.6	Jackson	S	P	3,180	5	*x*	*x*	3,238
218	175				43	Frio, Olig	S	P	4,788	17	AF	Vicksburg	8,138
219	21	2			25–39	Frio, Olig	S	P	3,300	15	AF	Mt. Selman	9,708
220	73	7			45	Frio, Olig	S	P	3,900	10	A	Yegua	6,113
221	29	2			46	Frio, Vicksburg, Olig	S	P	4,500	*x*	A	*x*	8,470
222	1	2											
223	47	2			43	Chernasky, Govt. Wells, Cockfield, Eoc	S	P	4,900	12	AFL	Yegua	7,005
224		30			23	Catahoula, Mio, Het., Olig	S	P	3,975	20	MF	Frio	6,926
225		27			21.1	Frio, Olig	S	P	2,050	15	NFL	Yegua	3,461
226	2	2			28	Frio, Olig	S	P	2,693	5	DF	Cook Mt.	7,666
227	2				46.8	Pettus, Yegua, Eoc	S	P	4,828	15	NF	Yegua	5,541
228	1				25.1	Frio, Olig	S	P	5,102	10	D	Vicksburg	8,724
229	6												
230	447	1			35.5	Frio, Olig	S	P	5,600	175	AFL	Frio	8,174
231	5	12			39	Jackson, Pettus, Eoc	S	P	3,065	11	DF	Wilcox	7,921
232		1			45	Cockfield, Eoc	S	P	3,632	10	DF	Cockfield	3,598
233	35	12			22–38	Catahoula Mio, Frio, Olig	S	P	3,860	8	DF	Frio	7,511
234	1				45	Frio, Olig	S	P	4,199	3	*x*	Frio	4,750
235	2	13			27	Catahoula, Olig	S	P	2,550	10	DLF	Vicksburg	5,252
236		38			21	Mirando, Eoc	S	P	2,450	12	MFL	Yegua	3,717
237	55	37			32	Frio, Vicksburg	S	P	4,800	10	NFL	Yegua	5,410
238	1	0	0										
239	1	1	0										
240	7	0	0		46	*x*	S	P	5,050	10	*x*	*x*	5,058
241	0	2	0										
242	1				43.6	Yegua, Eoc	S	P	5,240	10	F	Cook Mt.	5,313
243	403	2			26–40	Het., Marg., Frio, Olig	S	P	5,100	24	DF	Vicksburg	8,527
244	3	26			21.7	Yegua, Eoc	S	P	1,400	7	DLF	Yegua	1,785
245	4	2			20.4	Yegua, Eoc	S	P	1,814	8	SL	Yegua	3,382
246		1			24.8	Oakville, Mio, Het., Olig, Frio, Olig	S	P	1,900	8	AF	Frio	7,211
247	229	11			38.7	Oakville, Mio, Het., Olig, Catahoula, Olig, Frio, Olig	S	P	2,495	17	AF	Frio	8,483
248	59				30	Marg., Olig	S	P	7,600	40	AF	Frio	9,003
249	7				40	Frio, Olig	S	P	5,800	5	DF	Frio	6,710
250	2	4			36.5	Eoc	S	P	3,750	10	A	*x*	3,770
251													
252	14	1			43.3	Frio, Olig	S	P	4,210	10	MF	Yegua	4,889
253		1			48.1	Frio, Olig	S	P	4,600	10	*x*	Yegua	6,006

TABLE 2.—*Summary of Drilling Operations in South Texas*

Important Wildcats Drilled in 1944

	County	Location: Pool, Name	Location: Producing Depth	Total Depth	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.: Casing	Pressure, Lb. per Sq. In.: Tubing	Remarks
1	Goliad	Albrecht	8,350	10,958	Lissie	Wilcox	Continental Oil Co.	75	14.5	¼	Sealed	2,475	
2	Jim Wells	Almond	3,225	5,400	Lissie	Vicksburg	Wilcox O. & G. Co.	2	1.5	¼	1,300	900	
3	Victoria	Anagua	5,355	6,335	Beaumont	Frio	Gulf Oil Co.		40.0	Open flow	Sealed		
4	Refugio	Bonnie View	4,500	6,505	Lissie	Frio	Pat Rutherford	82		⅛	1,590	1,475	
5	Brooks	Boedecker	6,175	7,233	Lissie	Frio	Sun Oil Co.	9	.7	⅛	2,370	2,205	
6	Nueces	Brayton	7,200	7,419	Lissie	Frio	H. R. Smith	131		⅛	1,500	850	10 per cent water
7	Goliad	Cabeza Creek, South	8,210	9,018	Lissie	Wilcox	Continental & Atlantic	83	3.5	3/16	Sealed	2,700	
8	Jim Wells	Canales	7,235	7,237	Lissie	Frio	Sun Oil Co.	213		7/64	2,000	1,880	
9	Live Oak	Chapa	8,150	8,547	Goliad	Wilcox	Continental	34	1.8	⅛	Sealed	1,400	
10	Live Oak	Coquot	7,547	8,043	Oakville	Wilcox	H. Coquot		Gas well	Shut in		1,180	
11	Starr	Cortez	2,830	4,620	Reynosa	Vicksburg	Sun Oil Co.		30.0	Shut in			
12	De Witt	Cotton Wood Creek	7,630	9,017	Lagarto	Wilcox	Arkansas Fuel	20	5.2			2,200	
13	Nueces	Dougherty	5,550	6,520	Lissie	Frio	Hewitt & Daugherty	5	1.5	¼	Sealed	1,650	100 bbl. water
14	Duval	Eagle Hill, South	2,073	2,076	Frio	Jackson	Harvey & Henderson	22				Pumping	
15	Brooks	East Alta Mesa	7,650	8,106	Lissie	Frio	Standard of Texas		25.0	Open flow			
16	Karnes	Falls City	4,650	4,711	Lagarto	Wilcox	Southern Minerals	59		3/16	Sealed	125	120 bbl. water
17	Karnes	Green	6,540	6,543	Goliad	Wilcox	Magnolia Petr. Co.	68		¼	1,500	250	
18	San Patricio	Gregory	9,130	10,010	Beaumont	Frio	Humble O. & R. Co.	70	1.7	¼	Sealed	2,300	
19	Goliad	Goliad, North	2,680	2,695	Goliad	Vicksburg	Ginther		35.0	Open flow			
20	Duval	Herbst	2,830	2,980	Lissie	Jackson	Gorman	40				Pumping	81 bbl. water
21	Goliad		8,940	10,047	Lissie	Wilcox	Amerada Petr. Co.	36	1.3	⅛		4,150	
22	Starr	Jakalah	2,045	2,090	Reynosa	Jackson	T. E. Stephens		Gas well				Shut in
23	Victoria	Koontze	4,760	5,415	Lissie	Frio	E. Nelson	48		3/32	Sealed	350	
24	McMullen	Loma Alta Wilcox	6,875	7,103	Catahoula	Wilcox	Atlantic	102	1.0	9/64	Sealed	1,900	
25	Hidalgo	Los Indios	6,925	7,516	Lissie	Vicksburg	Baldridge & King		32.0	Open flow			
26	Victorio	Mission Valley	8,405	10,014	Goliad	Wilcox	Northern Ordnance	123	5.0	¼	Sealed	1,750	
27	Live Oak	Oakville Wilcox	6,955	6,960	Oakville	Wilcox	Coquot						Gas well, no gauge
28	San Patricio	Odem, North	5,430	7,225	Lissie	Frio	Texas Conservative	35		¼		Jetting	
29	Bee	Plummer-Wilcox			Goliad	Wilcox	Magnolia	70		7/64	Sealed	750	
30	Victorio	Pridham's Lake	4,770	4,907	Lissie	Frio	Kingwood Oil Co.	120		9/32	400	525	
31	Duval	Reyes	3,945	3,959	Reynosa	Pettus	American Republic	88		3/16	1,325	1,050	
32	Duval	Richardson	1,785	2,957	?	Yegua	T. Graham	20				Pumping	
33	Nueces	Riverside, East	6,300	7,230	Lissie	Frio	Stanolind Oil & Gas	154		⅛	Sealed	1,075	
34	McMullen	San Caja	6,910		Catahoula	Wilcox	E. M. Jones	53	35.0	¼	2,500	2,035	
35	Brooks	Scott & Hopper	6,870	6,912	Lissie	Frio	Humble O. & R. Co.	230		3/16	Sealed	840	
36	Jim Wells	Seiler	4,965	5,594	Lissie	Vicksburg	Highland Oil Co.		Gas well	Shut in	2,150	2,150	
37	Brooks	Dan Sullivan	8,512	8,522	Lissie	Frio	Sun Oil Co.	137		9/64	2,260	880	
38	Jim Wells	Tijerina	7,120	7,130	Lissie	Frio	Texas Co.	372		5/32	1,850	1,050	
39	Duval	?	4,315	5,142	Lissie	Yegua	Taylor Ref. Co.		2.3	¼	Sealed	1,560	
40	Jim Hogg	Vernodo	2,880	2,891	Reynoso	Jackson	Texas Co.		6.4	Open flow			
41	De Witt	Warmley	7,085	8,504	Lagarto	Wilcox	Sohio Oil Co.	35	.8	3/16	620	860	
42	Goliad	Weesatche	7,980	9,002	Goliad	Wilcox	Coffield	47	.2	⅛	2,600	2,100	
43	Goliad	Weesatche, South	8,500	9,003		Wilcox	Continental	81	4.0	¼	Sealed	2,450	

TABLE 3.—*New Sands and Extensions in South Texas in* 1944

Field	County	Avg. Pay Depth	Age Sand	Type Discovery	Discovery Well	Initial Production
Agua Dulce......	Nueces	7,330	Frio	Oil	Simmons & Perry No. 2-B Fee	121 bbl. per day ⅛-in. choke; tubing pressure 1025 lb.; casing pressure 1260 lb.
Agua Dulce......	Nueces	5,120	Frio	Oil	L. M. Lockhart No. 1 Ada Wright	94 bbl. per day; 9/64-in. choke; t.p. 450 lb. gas oil ratio 568:1; sp. gr. 32°
Armstrong.......	Jim Hogg	3,645	Jackson	Gas	Magnolia Petr. Co. No. 1 E. L. Armstrong	5,423 M cu. ft. per day; ½-in. choke; 860 lb. t.p.; 1120 lb. c.p.
Burnell-Wilcox...	Bee	7,017	Wilcox	Gas	Magnolia Petr. Co. No. 1 Eliz. Ingram	51,200 M cu. ft. open flow; initial pressure 2440 lb.
Burnell-Wilcox...	Karnes		Wilcox	Gas	Stanolind No. 1 T. Spielhagen	36,000 M cu. ft. per day; initial pressure 2450 lb.
Garcia..........	Starr	3,770	Frio	Gas	Sun No. 1 J. de Solis	120 lb. ⅛ in. choke; t.p. 610 lb.; c.p. 750 lb.
Longhorn........	Duval	5,205	Jackson	Oil	Hiawatha O. & G. No. 15 M. M. Miller	102 bbl. per day, 5/32 in. choke; t.p. 425 lb.; c.p. 150 lb. sp. gr. 42.4°
Magnolia City, North.	Jim Wells	5,450	Frio	Oil	H. H. Howell No. 1 L. J. Spoontz	298 bbl. per day 3/16 in. choke, t.p. 715 lb.; c.p. 800 lb. gas-oil ratio 497:1; sp. gr. 32°
Rincon..........	N. Starr	4,375	Frio	Oil	Sun Oil Co. No. 2-B D.D. Oil Co.	174 bbl. per day 9/64 in. choke; t.p. 599 lb.; c.p. 860 lb.
Garcia..........	Starr	3,730	Frio	Oil	Sun Oil Co. No. 6-B Frost Nat'l Bank	90 bbl. per day; 7/64 in. choke; t.p. 625 lb. Perforated 3375-86, 161 bbl. per day; 3/16 in. choke; c.p. 400 lb.
Thomas Lockhart	Duval	3,280 3,960	Jackson	Oil and Gas	Pan American No. 1 D. E. A. Parr	Perforated 3282–87 and 3271–76; 9½ million open flow; perforated 3966–71, 95 lb. oil plus 10 per cent SW 25 hr.; 5/32 in. choke; c.p. 425 lb.
Fox.............	Refugio	6,380	Frio	Oil	Hewitt & Dougherty No. 2-A, J. Hymes	180 bbl. per day; ⅛ in. choke; t.p. 1510 lb.; c.p. 2180 lb. gas-oil ratio 1631:1; sp. gr. 38°

One important development was the installation of a pressure maintenance project at Luby Oil field, Nueces County.

A gas line with a daily delivery capacity of 200,000,000 cu. ft., extending from Nueces County to West Virginia, was completed and put in operation during the year by the Tennessee Gas and Transmitting Co. Unless political action blocks undertakings of this type or new uses are discovered for gas, which will prohibit its consumption as a fuel, this project probably will be followed by other major transmission lines from the huge, dormant gas reserves of the Gulf Coastal area to the major centers of population in our nation.

TABLE 4.—*Wells Drilled in South Texas in* 1943 *and* 1944

Year	Total Wells Drilled	Oil	Gas	Dry
1943	982	495	63	424
1944	1,380	736	108	536
WILDCAT WELLS				
1943	330	30	5	295
1944	311	15	28	268

Oil and Gas Development in South Central Texas in 1944

By William H. Spice, Jr.,* Member A.I.M.E.

Exploratory drilling in South Central Texas for the year 1944 showed a marked increase over that of 1943 and resulted in a similar increase in new fields discovered. In this area, which comprises the 30 counties included in district No. 1, Oil and Gas Division, Railroad Commission of Texas,† 61 exploratory wells were drilled during 1944 as compared with 29 exploratory wells drilled during 1943, or an increase of over 100 per cent.

Three new oil fields, two new gas fields and one gas-distillate field were discovered during the year, as compared with one new oil field and one new gas field discovered during 1943.

These new fields were the result of exploratory drilling throughout the district along the Wilcox trend and the deeper Edwards lime trend, which was started during the previous year. The Wilcox trend yielded the new Loma Alta-Wilcox oil field and the San Caja gas-distillate field, both in McMullen County. The Charlotte field, in Atascosa County, was discovered along the deeper Edwards lime trend. These three discoveries were of considerable importance and subsequent development should indicate the desirability of continued exploration along these trends. The other three discoveries, United oil field in Guadalupe County, Pederson gas field in Milam County and Van Cleve gas field in Zavalla County, were of minor importance.

Charlotte Field, Atascosa County, was discovered by the Humble Oil and Refining Company's No. 3 Pruitt, completed on Aug. 9, 1944, flowing 176 bbl. per day, $^3/_{16}$-in. choke, 710 lb. tubing, 475 lb. casing pressures, 37.7° A.P.I. gravity, from the top of the Edwards lime from 6917 to 6923 ft. Two oil wells were completed during the year in this field. This discovery is 14 miles southwest of the same company's Imogene field, also producing from the Edwards lime but with considerable difference in reservoir characteristics. The discovery of this field is the result of surface geology and subsequent seismograph survey of the area.

Loma Alta-Wilcox Field, McMullen County, was discovered by the Atlantic Refining Company's No. 1 Atkinson, completed on June 1, 1944, flowing 102 bbl. per day, $^9/_{64}$-in. choke, 1900 lb. tubing pressure, 37° A.P.I. gravity, from Wilcox sand from 6866 to 6869 ft. after being drilled to a total depth of 7185 ft. This discovery is the result of subsurface geology and an extensive seismograph survey of the entire area.

San Caja Field, McMullen County, was discovered by Edwin M. Jones No. 2-C Ezzell, completed on June 2, 1944 as a dual completion in the Wilcox sands, flowing 1,740,000 cu. ft. gas with 53 bbl. distillate, ¼-in. choke, 2035 lb. tubing pressure, 53.2° A.P.I. gravity, from sand 6416 to 6453 ft. and flowing 2,000,000 cu. ft. of gas with 127 bbl. distillate, ¼-in. choke, 2500 lb. tubing pressure, 50° A.P.I. gravity, from sand 6889 to 6916 ft., after being drilled to a total depth of 7264 ft. Three gas-distillate wells were completed during

Manuscript received at the office of the Institute May 22, 1945.

* Consulting Geologist, San Antonio, Texas.

† A map of the districts appears in *Trans.* A.I.M.E. (1944) 155, 469.

TABLE 1.—*Oil and Gas Production in South Central Texas*

Line Number	Field, *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
1	Adams,* *Medina*	1926		0	0	2,000	*x*	38	58	0	0	0	0	4
2	Alta Vista, *Bexar*	1912	300	126,660	1,180				41	0	0	0	3	
3	Bee Creek, *Caldwell*	1940	320	274,167	7,968				33	0	9	0	16	
4	Branyon, *Caldwell*	1930	900	3,186,394	105,612				185	0	6	0	132	
5	Buchanan, *Caldwell*	1928	250	498,059	23,287				41	0	2	0	21	
6	Burdette Wells,[1] *Caldwell*	1936	200	60,848	45				12	0	2	0	0	
7	Byersville,[2] *Williamson*	1933	370	599,946	15,487				41	0	0	0	41	
8	Calliham,[3] *McMullen*	1918	500	1,110,944	30,853				142	0	3	0	56	
9	Campana,[4] *McMullen*	1938	10	831	0				1	0	0	0	0	
10	South Campana, *McMullen*	1941	180	195,593	70,666				15	0	0	14	0	
11	Carrizo, *Dimmit*	1941	20	6,689	298				1	0	0	0	0	
12	Carroll,[4] *Bastrop*	1932	100	101,547	0				9	0	0	0	0	
13	Cedar Creek, *Bastrop*	1932	100	314,883	7,794				13	0	0	0	7	
14	Chapman, *Williamson*	1928	450	4,504,754	45,484				70	0	0	0	70	
15	Charlotte, *Atascosa*	1944	80	15,170	15,170				2	2	0	2	0	
16	Chicon Lake, *Medina*	1929	450	118,291	9,539				83	0	0	0	74	
17	Chittim,* *Maverick*	1929	30	77,701	*x*	100	15,806	1,528	5	0	0	0	0	
18	Crowther,[5] *McMullen*	1915	80	25,000	0				23	0	0	0	0	
19	Dale,[6] *Caldwell*	1927	840	1,707,671	53,966				72	1	0	0	52	
20	Darst Creek, *Guadalupe*	1928	1,920	58,812,701	3,397,067				362	0	4	5	337	
21	Darst Creek Ext.,[7] *Guadalupe*	1935	200	393,791	2,251				11	0	0	0	2	
22	Day,[8] *Guadalupe*	1940	20	0	0				2	0	0	0	0	
23	Dunlap, *Caldwell*	1930	120	392,059	12,162				15	1	0	0	8	
24	Dunlay,[8] *Medina*	1938	30	1,988	0				1	0	0	0	0	
25	Eckert, *Bexar*	1927	850	975,219	18,837				121	0	3	0	98	
26	Elgin,[4] *Bastrop*	1941	10	3,565	0				1	0	0	0	0	
27	Elm Creek,[9] *Guadalupe*	1939	400	55,039	12,469				49	2	0	0	31	
28	Ezzell, *McMullen and Live Oak*	1937	1,500	3,261,221	228,211			231	152	1	3	0	124	3
29	Gas Ridge, *Bexar*	1912	150	125,816	11,534				128	2	0	0	66	
30	Green Branch, *McMullen*	1942	120	22,221	21,366		*x*	147	3	2	0	2	0	
31	Hilbig, *Bastrop*	1932	260	2,128,634	297,242				14	0	0	12	0	
32	Imogene, *Atascosa*	1942	480	153,714	123,506				12	9	0	12	0	
33	Jacob,[10] *McMullen*	1926	1,290	1,817,718	78,340				129	0	0	0	71	
34	Jones, *Bexar*	1921	20	3,128	240				3	0	0	0	3	
35	Kimbro, *Travis*	1935	40	5,941	670				4	0	0	0	4	
36	La Coste,[11] *Bexar*	1939	40	4,779	255		*x*	25	5	0	0	0	1	3
37	Larremore,[12] *Caldwell*	1927	80	359,398	0				13	0	0	0	0	
38	Lentz, *Bastrop*	1941	60	34,140	8,571				3	0	0	0	3	
39	Loma Alta, *McMullen*	1935	80	196,628	18,284				5	0	0	0	4	
40	Loma Alta-Wilcox, *McMullen*	1944	40	4,055	4,055				1	1		1	0	
41	Lone Oak,[8] *Bexar*	1934	10	4,485	0				1	0	0	0	0	

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Northeast Luling.
[2] Includes Mathews and Noack.
[3] Includes South Calliham.
[4] Abandoned 1942.
[5] Abandoned, date unknown.
[6] Includes West Dale and North Dale (Bateman).
[7] Clark.
[8] Abandoned 1940.
[9] Lavernia.
[10] Includes North Jacob.
[11] Fairfield.
[12] Abandoned 1943.

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Reservoir Pressure, Lb. per Sq. In.: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
1	*x*	*x*				Navarro and Taylor sands, CreU	S-Sh	P	900	*x*	F	Edwards lime	2,289
2	*x*			35	0.3	Navarro sands, CreU	S	15–20	220	20	F	Travis Peak	4,535
3	*x*			39	*x*	Dale lime, Serpentine, CreU	LP	P	2,050	*x*	Intn	Austin chalk	2,250
4	*x*			37	0.8	Austin chalk Edwards lime, CreU & L	L	P	1,816	*x*	F	Edwards lime	2,450
5	*x*			32	0.2	Serpentine, CreU	P	12	1,750	*x*	Intn	Edwards lime	2,483
6	200	*x*		36	0.8	Edwards lime, CreL	L	Crev	2,210	15	F	Edwards lime	2,420
7	*x*	*x*	G	37	0.2	Serpentine, CreU	P	20	850	*x*	Intn	Edwards lime	2,000
8	*x*			20 20.6 Gas	*x*	Mirando Govt. Wells, Pettus Loma Novio, Eoc	S	P	848 1,030 1,221	15 10 10	M F L	Carrizo	5,301
9	*x*	*x*		24	*x*	Government Wells, Eoc	S	P	2,492	20	MF	Pettus	3,102
10	*x*	*x*		22.8	*x*	Cole Government Wells Pettus, Eoc	S	P	1,864 2,554 3,012	3 10 12	MF	Cook Mountain	4,486
11	*x*	*x*		30	*x*	Navarro sands, CreU	S	26	2,300	4	MC	Taylor	3,120
12	*x*	*x*		36	0	Serpentine, CreU	P	12	2,300	78	Intn	Edwards lime	2,919
13	100	*x*		35	0.2	Serpentine, CreU	P	15–20	1,650	50	Intn	Edwards lime	2,300
14	400	*x*		36	0.2	Serpentine, CreU	P	20	1,750	20	Intn	Edwards lime	3,226
15	*x*	*x*		37.7	*x*	Edwards lime, CreL	L	P	6,917	6	F	Edwards lime	6,923
16	*x*	*x*		21	0.1	Navarro sands, CreU	S	15	260	20	D	Edwards lime	1,725
17	2,000	650		42–45	*x*	Glenrose, CreL	D	P	5,650	*x*	Af	Travis Peak	7,635
18	*x*	*x*		18	*x*	Diboll, Eoc	S	P	500	10	ML	Cook Mountain	2,000
19	150	*x*		37	0.2	Dale lime Serpentine, CreU	LP	15	1,915	30	Intn	Edwards lime	2,661
20	350	*x*		36	0.8	Edwards lime, CreL	L	P	2,650	30	F	Travis Peak	5,509
21	200	*x*		33.6	0.5	Austin chalk, CreU	C	5–25	2,375	100	F	Edwards lime	3,200
22	*x*	*x*		36	*x*	Austin chalk Buda lime, CreU & L	CL	P	2,377	*x*	F	Edwards lime	2,830
23	400	*x*		36	0.6	Austin chalk, CreU	C	Crev	2,375	15	F	Edwards lime	2,420
24	*x*	*x*		21	*x*	Serpentine, CreU	P	P	542	*x*	Intn	Austin chalk	851
25	*x*	*x*		34	0.3	Navarro sands, CreU	S	16	620	10	F	Edwards lime	1,590
26	*x*	*x*		36	*x*	Austin chalk, CreU	C	Crev	2,820	20	F	Edwards lime	3,352
27	*x*	*x*		40–42	*x*	Navarro sands, CreU	S-Sh	P	700	*x*	T	Navarro	800
28	*x*	*x*	G	20	*x*	Loma Novio, Eoc	S	P	1,490	11	ML	Cook Mountain	3,180
29	*x*	*x*		22	0.4	Navarro sands, CreU	S	15–20	230	15	A	Travis Peak	3,460
30	*x*	*x*		28.2 Gas	*x*	Reklaw, Eoc Wilcox, Eoc	S S	P P	3,935 5,720	*x* 6	F	Navarro	7,623
31	1,240	*x*	P	37	0.2	Serpentine, CreU	P	12	2,450	50	Intn	Edwards lime	3,250
32	3,280	*x*		39	*x*	Edwards lime, CreL	L	P	7,570	30	F	Glenrose	9,390
33	*x*	*x*		Gas 21.5 20.5	*x*	Mirando Pettus Yegua, Eoc	S	P	1,050	8 7 8	ML	Mt. Selman	3,171
34	*x*	*x*		*x*	*x*	Navarro sands, CreU	S-Sh	P	600	*x*	T	Edwards lime	2,008
35	*x*	*x*		36.5	*x*	Serpentine, CreU	P	P	660	*x*	Intn	Edwards lime	1,280
36	*x*	*x*		31	*x*	Anachacho lime, CreU	L	P	1,150	*x*	N	Edwards lime	1,800
37	*x*	*x*		23	0.6	Edwards lime, CreL	L	P	1,285	35	F	Travis Peak	3,360
38	*x*	*x*		36	*x*	Dale lime, CreU	L	P	2,226	18	F	Austin chalk	2,453
39	*x*	*x*		21	*x*	Chernosky, Eoc	S	P	2,195	12	MFL	Cockfield	2,766
40	*x*	*x*		37	*x*	Wilcox, Eoc	S	P	6,838	30	AF	Wilcox	7,185
41	*x*	*x*		33.4	*x*	Navarro-Taylor, CreU	S	P	1,480	18	F	Edwards lime	2,250

the year. This discovery is 16 miles northeast of the new Loma Alta-Wilcox field and along the same general trend. It is the result of a detailed seismograph survey of the area.

Pederson Field, Milam County, was discovered by Pederson et al. No. 1 Yoakum, completed on May 7, 1944, flowing an estimated 3,000,000 cu. ft. of gas, open flow, from Navarro sand encountered from 1352 to 1357 feet.

United Field, Guadalupe County, was discovered by the United North and South Development Company's No. 1 Webb, completed on May 19, 1944, flowing 213 bbl. per day, 3/16-in. choke, 175 lb. tubing, 225 lb. casing pressures, 35° A.P.I. gravity, after acidizing with 1000 gal. of acid. This well was drilled originally to a total depth of 2808 ft., plugged back and completed in the upper part of the Austin chalk from 2582 to 2614 ft. This discovery

TABLE 1.—(*Continued*)

Line Number	Field, County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production: Area Proved, Acres[d]	Gas Production: Millions Cu. Ft.[e] To End of 1944	Gas Production: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
42	Luling, *Caldwell and Guadalupe*	1921	2,200	81,795,558	1,772,750				606	0	0	0	596	
43	Lytton Springs, *Caldwell*	1925	1,360	8,840,153	81,457				157	0	12	0	122	
44	Manda,[4] *Travis*	1935	40	25,269	0				3	0	0	0	0	
45	Manford, *Guadalupe*	1929	40	428,125	6,266				1	0	0	0	1	
46	Minerva-Rockdale, *Milam*	1921	4,250	3,866,549	55,925				425	2	0	0	408	
47	Munson, *McMullen*	1938	150	214,552	13,007				17	0	0	0	11	
48	Nash Creek,[13] *Guadalupe*	1936	10	46,535	0				1	0	0	0	0	
49	Pearsall, *Frio*	1933	1,160	2,329,289	393,008				44	7	0	16	27	
50	Pendencia Creek,* *Dimmit*	1941	0	0	0	1,320			3	0	0	0	0	
51	Philtop,[4] *Bexar*	1938	40	8,171	0				8	0	0	0	0	
52	Rhode,* *McMullen*	1936		0	0	1,200	*x*	1,157	11	0	0	0	0	
53	Riddle, *Bastrop*	1938	50	104,797	10,780				7	0	1	0	2	
54	Salt Flat, *Caldwell*	1928	1,300	45,051,242	709,986				298	0	20	0	248	
55	San Caja,* *McMullen*	1944	0	*x*	*x*	960	216	216	3	3	1	0	0	3
56	San Jose,[14] *McMullen*	1938	10	450	0				2	0	0	0	0	
57	Somerset, *Atascosa and Bexar*	1912	11,390	11,216,600	65,514				915	0	119	0	338	
58	Southton-Yturria, *Bexar*	1921	650	715,605	13,717				103	0	0	0	103	
59	Spiller, *Guadalupe*	1938	30	26,527	3,405				6	0	0	0	3	
60	Taylor-Ina, *Medina*	1922	380	160,775	246				17	0	0	0	0	
61	Tenney Creek, *Caldwell*	1940	150	413,269	113,695				25	0	4	12	9	
62	Thrall, *Williamson*	1914	475	2,537,705	21,267				27	0	0	0	21	
63	United, *Guadalupe*	1944	40	7,731	7,731				2	2	0	2	0	
64	Van Cleve,* *Zavalla*	1944	0	0	0	40	0	0	1	1	0	0	0	
65	Von Ormy, *Bexar*	1933	650	326,381	16,715				109	0	16	0	86	
66	Walnut Creek,[15] *Caldwell*	1938	50	8,974	0				3	0	0	0	0	
67	Washburn,[16] *LaSalle*	1940	500	557,936	339,046				25	2	0	21	0	
68	Wentz,* *McMullen*	1932	0	0	0	80	*x*	0	3	0	0	0	0	
69	Yost, *Bastrop*	1928	120	934,451	6,801				7	1	0	0	5	
70	Zoboroski, *Guadalupe*	1935	180	275,170	15,398				14	0	0	0	14	
71	Totals		38,125	241,583,202	8,269,123	5,700	16,022	3,342	4,725	39	205	99	3,218	29

[13] Abandoned 1941.
[14] Abandoned 1939.
[15] Abandoned 1944.
[16] Includes South Washburn.

is the result of subsurface geology and trend drilling in the faulted area southwest of the Salt Flat Field of Caldwell County.

Van Cleve Field, Zavalla County, was discovered by The Texas Company's No. 1 Van Cleve, completed on June 18, 1944, flowing an estimated ¾ million cubic feet of dry gas, 5⁄16-in. choke, 510 lb. tubing pressure from Navarro sand from 1960 to 1965 ft., after being drilled to a total depth of 2538 ft. This discovery is the result of extensive surface geological work carried out in the area.

Production for this district during 1944 totaled approximately 8,269,000 bbl. from about 3300 producing wells. This is an increase in production of about 18 per cent over 1943 but a decrease in producing wells of about 3 per cent under the number of wells producing in 1943. Average daily production per well was 6.8 bbl. during 1944 as against 5.4 bbl. during 1943. Ap-

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
42	1,500	x		27	0.9	Edwards lime, CreL	L	25	2,100	50	F	Schist	7,859
43	1,250	x		31.5	0.4	Serpentine, CreU	P	12	1,535	x	Intn	Edwards lime	2,050
44	x	x		34	0.4	Serpentine, CreU	P	15–25	720	x	Intn	Taylor marl	850
45	1,250	x		37	0.9	Austin chalk, CreU	C	35	2,260	30	F	Edwards lime	2,800
46	x	x		38	0.2	Navarro sands, CreU	S-Sh	P	600	15	T	Edwards lime	5,000
47	x	x		20.7	x	Mirando, Eoc	S	P	1,200	12	ML	Pettus	1,501
48	340	x		27	0.8	Taylor marl, CreU	SL	P	2,570	30	F	Edwards lime	3,342
49	1,500	x		28	0.4	{ Navarro sands, CreU Austin chalk, CreU Buda lime, CreL }	SC	P	{ 3,920 5,400	30 x }	Af	Travis Peak	10,050
50	x	x				Navarro sands, CreU	S	P	{ 1,084 1,885 }	x	A	Taylor marl	3,005
51	x	x		23	x	Austin chalk, CreU	C	P	1,100	x	F	x	x
52	x	x				Cole, Eoc	S	P	1,800	12	MFL	Yegua	3,534
53	x	x		39	x	{ Austin chalk Serpentine, CreU }	CP	P	1,667	x	F	Austin chalk	1,777
54	200	x		36	0.6	Edwards lime, CreL	L	30	2,670	25	F	Edwards lime	2,918
55	x	x		51.5	x	Wilcox sands, Eoc	S	P	{ 6,416 6,882	37 34 }	AF	Wilcox	7,264
56	x	x		23	x	Cole, Eoc	S	P	1,147	16	ML	Yegua	2,370
57	300	x		36	1.4	Navarro and Taylor sands, CreU	S-Sh	22	1,200	30	TF	Travis Peak	5,311
58	x	x		32	0.5	Navarro sands, CreU	S	16	600	10	FL	Glenrose	3,850
59	x	x		38.3	x	Buda lime, CreL	L	P	2,012	x	F	Edwards lime	2,382
60	x	x		18–19	0.5	Navarro sands, CreU	S-Sh	15	{ 290 940	16 10	F T }	Edwards lime	2,048
61	x	x		38	x	{ Austin chalk, CreU Buda lime, CreL }	CL	P	2,340	60	F	Buda lime	2,705
62	400	x		37	0.5	Serpentine, CreU	P	25	700	75	Intn	Travis Peak	3,290
63	x	x		35	x	Austin chalk, CreU	C	P	2,582	30	F	Del Rio	2,808
64	840	x				Navarro sands, CreU	S	P	1,960	5	N	Taylor marl	2,538
65	x	x		34	0.4	Navarro sands, CreU	S-Sh	10	506	20	F	Edwards lime	2,835
66	x	x		36	x	Serpentine, CreU	P	P	1,230	100	Intn	Austin chalk	1,900
67	x	x		41	x	Wilcox sand, Eoc	S	P	4,860	30	AF	Navarro	8,300
68	x	x				Cole, Eoc	S	P	370	12	ML	Yegua	1,654
69	400	x		27	0.3	Serpentine, CreU	P	20	1,335	100	Intn	Edwards lime	2,600
70	150	x		30.4	0.8	Austin chalk, CreU	C	10	2,050	75	F	Edwards lime	2,600
71													

proximately 5,985,000 bbl. of this total production, or 72 per cent, was produced by the four Edwards lime fields, Luling, Branyon, Salt Flat and Darst Creek, which are from 23 to 15 years old. Production from these fields was increased 12.5 per cent over the 1943 production, with no new wells drilled in these fields.

Drilling in the other proven fields was increased considerably during the year, a total of 105 field wells having been drilled. Of these, 33 were oil wells and 72 were dry holes. This is a slightly lower proportion of producers to dry holes than for 1943. Imogene field had the greatest number of new producing wells drilled during the year, with a total of nine. Pearsall field had seven new producers and the remaining new producers were scattered among nine other fields in the district.

FIG. 1.—LOCATION OF OIL AND GAS FIELDS, SOUTH CENTRAL TEXAS.

The old fields of Somerset and Minerva-Rockdale, in which more than 250 marginal wells were abandoned during 1943 because of rising operating costs and material and manpower shortages, showed declines in 1944 production of 25 and 15 per cent, respectively.

Several inactive wells in Luling field

were successfully plugged back with plastic, increasing production 8 per cent in 1944 from this old field.

Exploratory work in the district was confined mainly to areas along the Wilcox trend and the deeper Edwards lime trend. There was some activity also in the Edwards plateau, in the northwestern part of the district. Leasing has been most active along these trends and a considerable amount of geological and geophysical work was carried out in the areas favorable for deeper lower Cretaceous and possible Jurassic production.

ACKNOWLEDGMENT

Appreciation is expressed by the author to many companies and individuals for their cooperation in furnishing much of the production and well data shown on Table 1.

Developments in West Texas Oil Fields during 1944

By R. S. Dewey,* Member A.I.M.E.

More wells were drilled in West Texas† during 1944 than in any year since 1941. As compared with 1943, there was an 82.5 per cent increase in the total number of completed wells. The 1646 wells required an estimated 140,715 days to complete for a total of 7,632,249 ft. An average of 85 completion days was required to drill to an average of 4630 ft. This depth is approximately 100 ft. greater than that of the previous year. It is estimated that $100,000,000 was invested in drilled wells. As of Dec. 31, 1944, there were 270 field and 91 wildcat wells being drilled. While an identical number of wells were drilling Dec. 31, 1943, the proportion of wildcats increased in 1944 from 19.7 to 25.2 per cent.

During 1944, oil wells were completed in 103 of the 164 fields in West Texas. Of the 1361 oil wells, 385 were in Slaughter, 116 in Fullerton, 63 in North Cowden, 62 in Fuhrman-Mascho, 59 in Wasson, 52 in Westbrook and 47 in North Ward. Approximately 22 per cent of the wildcat drilling was to pre-Permian formations. Despite the increasing proportion of wildcat wells drilled, the wildcat discovery rate has declined since the year 1942. As compared with 1943, the number of wildcat wells drilled increased from 11.7 to 12.7 per cent and the footage in wildcat exploration increased from 13.3 to 13.8 per cent of the total.

The monthly production of crude continued to increase to a peak of 15,336,000 bbl. in October 1944. As compared with a similar peak production in October 1943, there was a 37.3 per cent increase. The yearly production increased from 98,165,000 bbl. in 1943 to 159,943,000 bbl. in 1944, an increase of 62.8 per cent. Based upon an assumed average price of $1.00 per barrel and less ⅛ royalty, the gross return to the producer amounts to $140,000,000. From 1943 to 1944, the average number of producing wells increased 6 per cent while the average daily production per well increased 53.1 per cent. The average daily production per well increased from 17.5 bbl. in 1943 to 26.8 bbl. in 1944. The proportion of flowing wells decreased from 50.5 per cent in January to 49.1 per cent in December 1944.

Drilling

With the continued shortage of labor and materials, drilling costs have risen sharply. Just how much is difficult to ascertain. Owing to competition for available drilling rigs, contractors are reluctant to assume drilling risks. In consequence, some contracts are let on a cost plus basis, or day work below some specified depth with the operator furnishing part of the consumable materials, such as mud and drilling bits. Contractors are having difficulty in maintaining full and effective drilling crews with insufficient and inexperienced labor. Service companies have inadequate labor and equipment to meet their appointments promptly.

Pipe Lines

The Gulf Pipe Line Co. increased the capacity of its 10-in. main line by filling in gaps amounting to 75 miles on the loops between Judkins and Weatherford, Texas.

Manuscript received at the office of the Institute April 18, 1945.

* Humble Oil and Refining Co., Midland, Texas.

† A map showing all Texas oil and gas districts appeared in *Trans.* A.I.M.E. (1944) **155**, 469.

TABLE 1.—*Oil and Gas Production in West Texas*

Line Number	Field,[1] *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production[2]: Area Proved, Acres[d]	Gas Production[2]: Millions Cu. Ft.[e] To End of 1944	Gas Production[2]: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
1	Abell, *Pecos*	1940	4,000	3,029,613	1,142,717			2,591	91	2	0	78	8	5
2	McKee Sand	1940	2,845						61	0	0	59	0	2
3	Simpson Dolomite	1943	40						1	0	0	1	0	0
4	Waddell Sand	1941	500						14	0	0	9	0	3
5	Ellenburger	1941	615						15	2	0	9	8	0
6	Abell Permian, *Pecos*	1941	920	327,027	141,315			114	26	1	0	13	10	0
7	2300-foot pay	1941	320						10	1	0	6	3	0
8	3200-foot pay	1941	40						2	0	0	1	0	0
9	3350-foot pay	1941	40						1	0	0	0	0	0
10	3800-foot pay	1941	240						6	0	0	4	2	0
11	3900-foot pay	1941	280						7	0	0	2	5	0
12	Apco 1600, *Pecos*	1943	400	34,797	34,232				7	6	0	7	0	0
13	Apco-Warner, *Pecos*	1939	2,000	1,232,753	648,653			590	44	5	0	39	3	1
14	Barnhart, *Reagan*	1941	5,600	1,280,571	923,496				37	12	0	37	0	0
15	Beddo, *Runnels*	1938	70	152,231	21,450				7	0	0	0	7	0
16	Big Lake, *Reagan*	1923	3,300						308	0	1	6	185	3
17	2400-foot pay	1923	300						21	0	1	0	7	0
18	3000-foot pay	1923	3,000	71,930,902	1,127,238				261	0	0	0	170	0
19	4300-foot pay	1942	40						1	0	0	1	0	0
20	Ordovician	1928	1,300	29,461,529	407,357				25	0	0	5	8	3
21	Blackwell, *Coke*	1942	40	6,846	930				1	0	0	0	1	0
22	Bolt, *Kimble*	1939	40	2,984	378				2	0	0	1	1	0
23	Byrd, *Ward*	1942	280	98,861	46,288		110	62	7	0	0	6	1	0
24	Cedar Lake, *Gaines*	1939	3,000	1,823,348	794,538				57	3	0	0	56	0
25	Chancellor, *Pecos*	1942	80	61,540	22,076			17	2	0	0	1	1	0
26	Clabberhill, *Andrews*	1943	160	17,622	14,539		11	9	2	1	0	1	1	0
27	Clara Couch, *Crockett*	1941	600	93,124	64,835				14	4	0	1	11	2
28	Crane-Cowden, *Crane and Upton*	1926	2,160	5,682,316	134,998				141	0	0	0	95	0
29	Crockett, *Crockett*	1938	1,140	538,091	87,969				41	3	0	8	33	0
30	Crossett, *Crane and Upton*	1944	400	30,992	30,992			53	5	5	0	5	0	0
31	Dean, *Cochran*	1937	2,000	273,077	130,493		243	94	14	4	0	3	11	0
32	Deep Rock, *Andrews*	1930	600	781,919	31,121			11	15	2	1	2	11	0
33	Dobbs, *Ward*	1936	80	23,665	1,696				2	0	0	0	1	0
34	Doss, *Gaines*	1944	640	1,408	1,408			1	1	1	0	1	0	0
35	Dune, *Crane*	1938	2,200	929,731	202,557		547	117	32	4	1	7	23	0
36	Eaves, *Winkler*	1936	760	1,367,721	463,018			275	21	11	0	5	16	0
37	Edwards, *Crane*	1935	120	23,637	2,178				1	0	0	0	1	0
38	Ella Waddell, *Crane*	1940	400	118,976	36,245		44	12	5	0	0	1	4	0
39	Embar,[3] *Andrews*	1942	1,240	1,444,500	975,614		652	438	21[3]	4	0	21	0	0
40	Embar Permian,[3] *Andrews*	1942	1,200	572,950	277,369		832	440	14[3]	2	0	14	0	0
41	Emma, *Andrews*	1937	2,000	2,461,906	849,354			600	72	3	0	8	63	0
42	Emperor, *Winkler*	1935	1,840	3,322,324	439,125			1,401	92	6	3	76	8	4
43	Emperor Deep, *Winkler*	1940	2,000	1,106,142	89,041			129	51	2	2	22	17	6
44	Estes,[4] *Ward*	1936	4,500	17,214,479	1,595,082		54,899	6,323	373	5	0	193[4]	147	7
45	Fort Stockton,[5] *Pecos*	1944	400	14,141	14,141		35	35	4	4	0	3[5]	1	1[5]
46	Foster, *Ector*	1936	13,000	24,221,617	6,159,652			3,246	585	2	0	234	351	0
47	Fromme, *Pecos*	1939	320	120,860	10,025				11	0	0	5	2	1
48	Fuhrman-Mascho,[6] *Andrews*	1930	8,000	5,019,655	1,284,946			2,029	180	62	0	65	112	3
49	Fullerton,[7] *Andrews*	1942	25,000	3,239,072	2,776,772		2,878	2,527	147	116	0	142	5	0
50	Fullerton 3100 ft., *Andrews*	1944	80						2	1	0	1	0	1
51	Fullerton 8500 ft., *Andrews*	1944	640	27,785	27,785		10	10	1	1	0	1	0	0
52	Funk, *Tom Green*	1940	320	2,223	1,140				14	13	0	0	8	0
53	Garza, *Garza*	1935	360	139,518	10,528				18	1	0	0	5	0

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] No production reported from the Anthony, Bean, Carter, Dodson, Grassroots, Simpson and Stinnett fields.
[2] Gas production estimated from annual gas-oil ratio tests. Gas volume not accurate.
[3] Embar-Embar Permian: three dual completions.
[4] Estes: some wells shut in; transfer of allowable.
[5] Fort Stockton: one dual gas and oil completion.
[6] Fuhrman and Mascho combined.
[7] East Fullerton combined in Fullerton.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
1												Ellenburger	6,483
2	2,550	1,895		43		Simpson, Ord	S	P	5,270	20	A		
3				42	1.5	Simpson, Ord	D	P	5,711	20	AF		
4	2,726	2,050		41		Simpson, Ord	S	P	5,725	10	A		
5	2,768	2,608		41	4.4	Ellenburger, Ord	D	Frac.	5,800	30	AF		
6													
7	1,225			36	0.6	San Andres, Per	D	P	2,275	20	A	Pre-Cambrian	5,745
8	1,765			26	2.0	Lower San Andres, Per	D	P	3,210	25	A	Ellenburger	6,483
9	1,848			34	0.8	Upper Clear Fork, Per	D	P	3,350	20	A	Ellenburger	6,483
10	1,778			35	0.4	Wichita, Per	D	P	3,750	30	A	Pre-Cambrian	5,745
11	1,669			37	0.9	Wichita, Per	D	P	3,895	30	A	Ellenburger	6,483
12				35		Queen, Per	S	P	1,658	12	A	Queen	1,705
13				41	0.3	Ellenburger, Ord	D	Cav	4,550	20	A	Pre-Cambrian	4,526
14	3,915			44		Ellenburger, Ord	D	P	9,058	75	A	Ellenburger	9,301
15				42		Pen	S	P	2,366	22	N		
16												Ellenburger	9,562
17				35	0.3	Queen, Per	S	P	2,375	40	A		
18				36	0.4	San Andres, Per	L-D	P	2,960	60	AD		
19						Clear Fork, Per	S	P	4,212		MC		
20	3,600			44	0.1	Ellenburger, Ord	D	P	8,200		A		
21				41		Cisco, Pen	L	P	3,821	7		Cisco	3,828
22				27		Strawn, Pen	S	P	1,415	10	AF	Ellenburger	2,074
23	1,435	804		30	1.6	Yates, Per	S-D	P	2,607	16	A	Queen	2,885
24	1,954			33	2.1	San Andres, Per	D	14.3	4,800	25	A	Strawn-Bend	11,954
25	1,915			36		Delaware, Per	S	P	5,075	5	H	Delaware	6,001
26				33		San Andres, Per	LS	P	5,464	86		Clear Fork	7,500
27	950			26		Grayburg-San Andres, Per	D	P	{1,530 {2,222	8	A	San Andres	2,230
28				28	2.4	Grayburg, Per	D	10	2,250	10	A	San Andres	2,750
29				31	1.7	Grayburg, Per	DS	P	1,330	7	A	San Andres	1,635
30	2,500	2,500		45		Lower Dev	Ch-L	P	5,300	60	A	Simpson	6,021
31	1,775	1,269		29		San Andres, Per	D	P	4,900	12		Clear Fork	6,621
32	1,800			28		San Andres, Per	D	P	4,288	20	A	Ordovician	11,812
33				37		Queen, Per	S	P	2,550	7		Grayburg	2,600
34	2,800	2,772		33.6		Clear Fork, Per	D	P	7,030	15	A	Wolfcamp	9,049
35				34	1.5	Grayburg, Per	DL	Poor	3,150	15	A	San Andres	3,795
36				26		Yates, Seven Rivers, Per	S-SD	P	3,100	20	A	Seven Rivers	3,175
37						Grayburg, Per	D	P	3,315		A	San Andres	3,695
38	1,375			35		Grayburg, Per	D	P	3,250	20	A	San Andres	3,734
39	3,271			47		Ellenburger, Ord	D	2.39	7,835	223	A	Pre-Cambrian	8,015
40	2,341			43	2.1	Clear Fork, Per	D	6.1	6,200	100	A	Pre-Cambrian	8,015
41	1,500			34		San Andres, Per	D	P	4,190	25	A	San Andres	4,541
42	1,300			33		Yates, Per	S-SD	18.8	2,700	65	A	San Andres	3,480
43						Seven Rivers, Per	OD	P	2,785	20	AC	Seven Rivers	3,100
44	1,375		W	34	1.2	Yates, Seven Rivers, Per	S-D	P	{2,450 {2,850 {3,000	40	A	Queen	3,274
45	1,400	1,265		36		Yates, Seven Rivers, Per	S-D	P	2,840	22	A	Delaware	4,903
46	1,740			35	1.1	Grayburg, Per	DS	11	4,100	42	A	San Andres	5,500
47				32		Queen, Per	S-D	P	1,412	15	A	San Andres	1,674
48	1,800			30	4.2	San Andres, Per	D	P	4,344	20	A	Wichita	7,810
49	3,000	2,835		43	0.5	Clear Fork, Per	D	P	7,045	100	A	Devonian	8,955
50						Yates, Per	S	P	3,050	10	A	Devonian	8,955
51	3,624	3,624		40		Upper Dev	D	P	8,460	100	A	Devonian	8,955
52				35		San Andres, Per	DL	P	4,123	4	MC	Clear Fork	1,560
53						San Andres, Per	DL	P	2,800	20	A	San Andres	2,940

TABLE 1.—(*Continued*)

Line Number	Field,[1] *County*[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production[2]: Area Proved, Acres[d]	Gas Production[2]: Millions Cu. Ft.[e] To End of 1944	Gas Production[2]: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil Flowing	Wells Producing[g] Dec. 1944: Oil Artificial Lift	Wells Producing[g] Dec. 1944: Gas
54	Goldsmith,[8] *Ector*	1934	24,500	55,220,105	8,641,232		116,615	17,615[8]	1,015	17	0	927	78	6
55	Grayson, *Reagan*	1928	400	712,275	34,785				9	2	0	1	6	0
56	Halley,[9] *Winkler*	1934	1,320	1,224,511	183,020			459	43	13	0	16	24	2
57	Halley Extension,[9] *Winkler*	1943	160	4,580	1,494[9]				4	3	0	3	1	0
58	Harper, *Ector*	1933	4,000	9,070,984	591,176			735	184	0	0	20	164	0
59	Heiner, *Pecos*	1941	80	27,196	10,157			35	2	0	0	2	0	0
60	Henderson, *Winkler*	1933	1,650	9,792,969	1,851,809				143	0	4	87	48	1
61	Henderick, *Winkler*	1926	12,200	208,156,642	1,737,833				425	0	22	37	216	1
62	Herrington,[10] *Upton*	1937	100	97,812	6,171[10]				2	0	0	0	2	0
63	Hoover, *Crockett*	1941	80	7,801	357				2	0	0	0	2	0
64	Howard Glasscock, *Glasscock and Howard*	1926	18,000	113,928,995	4,816,780				982	15	1	3	838	0
65	1400-foot pay	1927	3,000						208	5	1	0	182	0
66	1800-foot pay	1926	3,000						199	0	2	0	140	0
67	2200-foot pay	1929	6,000						267	0	0	0	237	0
68	2500-foot pay	1928	2,000						94	10	0	3	80	0
69	3000-foot pay	1928	4,000						214	0	1	0	199	0
70	Huddleston, *Runnels*	1940	20	21,712	2,941				2	0	0	1	0	0
71	Hurdle, *Upton*	1936	300	269,275	12,327				18	0	0	0	12	0
72	Iatan-East Howard, *Howard and Mitchell*	1926	8,000	19,152,636	1,431,820				355	30	0	3	342	0
73	Iatan, North, *Howard*	1943	400	78,173	70,359				10	9	0	6	4	0
74	Irion, *Irion*	1929	340	143,389	2,574				18	1	0	0	2	0
75	Jamison Pollard, *Pecos*	1941	40	83,090	12,997				1	0	0	1	0	0
76	Johnson, *Ector*	1935	7,520	4,053,747	1,381,773			1,071	127	1	0	70	57	0
77	Jordan, *Crane and Ector*	1937	5,620	9,780,844	2,380,462			1,523	240	1	3	155	67	0
78	Kermit, *Winkler*	1928	15,240	31,995,300	1,024,758		98,867	5,039	848	0	31	100	647	36
79	Kermit Ellenburger, *Winkler*	1943	680	153,609	98,250				2	1	0	2	0	0
80	Keystone Colby, *Winkler*	1930	8,080	7,801,603	1,367,991			2,505	294	20	8	186	91	1
81	Keystone Ellenburger, *Winkler*	1943	7,000	501,690	460,662		705	624	13	12	0	13	0	0
82	Keystone Holt, *Winkler*	1943	6,200	194,947	191,340		268	265	9	8	0	9	0	0
83	Keystone Lime, *Winkler*	1935	9,500	5,164,254	432,858		58,667	2,799	108	3	0	64	40	6
84	Leck, *Winkler*	1927	960	4,205,879	157,568				11	2	0	2	9	0
85	Lehn,[11] *Pecos*	1939	1,200	516,462	63,176			71	60	6	1	20	37	0
86	Lion, *Ward*	1944	320	4,839	4,839		4	4	1	1	0	1	0	0
87	Live Oak, *Crockett*	1940	40	4,904	1,626				1	0	0	0	1	0
88	Lubbock, *Lubbock*	1941	40	8,535	3,520				1	0	0	0	1	0
89	Mabee, *Andrews*	1943	3,840	358,401	358,401		35	35	32	32	0	3	29	0
90	Magnolia Sealy, *Ward*	1938	830	1,365,631	150,063			71	55	0	0	1	52	0
91	Magnolia Sealy, South, *Ward*	1940	1,020	751,650	245,416		393	145	20	0	2	13	4	0
92	Mason, *Loving*	1937	350	600,599	49,717			44	10	0	1	6	2	0
93	Masterson, *Pecos*	1929	240	1,059,344	39,351			8	24	0	3	0	21	0
94	Masterson 3500 ft., *Pecos*	1943	40	41,516	28,842				1	0	0	1	0	0
95	McCamey, *Crane and Upton*	1925	19,200	60,934,083	3,300,666				1,114	3	12	1	811	0
96	McElroy, *Crane and Upton*	1926	15,000	143,594,471	10,415,809		106,425	10,270	620	20	0	87	529	2
97	McKee, *Crane*	1942	240	84,821	41,797				3	1	0	0	3	0
98	McMillan, *Runnels*	1927	190	960,336					18	0	0	0	0	0
99		1942	20	4,348	2,081				2	0	0	1	0	0
100	Means, *Andrews*	1934	6,400	8,141,472	1,289,698		7,597	637	132	4	0	58	71	2
101	Melvin, *McCullough*	1938	100	829	570				1	0	0	0	1	0
102	Monahans, *Ward*	1942	560	263,746	139,256		447	301	4	3	0	4	0	0
103	Monahans, North, *Winkler*	1944	920	35,555	35,555		93	93	4	4	0	4	0	0
104	Monahans, Permian, *Ward*	1942	320	29,583	13,004		26	12	1	0	0	1	0	0
105	Monroe, *Ward*	1930	80	91,454	6,123				2	0	0	1	0	0
106	Moore, *Howard*	1937	720	139,046	27,673				18	10	0	0	17	0
107	Morita, *Howard*	1944	200	2,637	2,637				4	4	0	0	3	0
108	Netterville, *Pecos*	1934	800	428,344	19,495				22	0	0	11	5	0
109	Noelke, *Crockett*	1940	1,200	669,558	298,457				52	7	0	35	9	1
110	North Cowden, *Andrews and Ector*	1930	27,000	37,038,665	9,131,163			8,866	630	63	0	401	222	2

[8] Goldsmith processed gas.
[9] Halley extension combined with Halley; one month's production.
[10] Herrington combined with McCamey; 9 months' production.
[11] Three wells. Debs prorated in Lehn.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness, Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
54	1,700	1,221		36	1.9	San Andres, Per	DL	10–15	4,180	65	A	San Andres	4,557
55				33	0.6	San Andres, Per	OD	P	3,098	14	D	Strawn	9,969
56	1,235			31		Yates, Seven Rivers, Per	S-SD	P	2,730	65	A	San Andres	3,855
57				33		Seven Rivers, Per	DS	P	3,191	30	A	Seven Rivers	3,194
58				37	1.2	San Andres, Per	D	P	4,000	20	MC	San Andres	4,518
59				35		Ellenburger, Ord	D	P	5,382			Ellenburger	5,665
60	1,350	1,280		30	1.1	Yates, Seven Rivers, Per	OD	P	3,025	30	A	Grayburg	3,450
61	1,350			28	1.5	Yates, Seven Rivers, Per	OD	P	2,600		A	San Andres	3,920
62				24		Grayburg, Per	DL	P	2,950	20	A	Grayburg	2,963
63				26		Queen, Per	S	P	1,425	10	N	San Andres	2,173
64											A	Ellenburger	10,906
65				32	1.0	Yates, Per	S	P	1,280	20			
66				32	0.8	Seven Rivers, Per	S	20	1,650	20			
67				30	1.6	Grayburg, Per	DL	P	2,150	30			
68				30	0.9	San Andres, Per	DL	P	2,400	30			
69				27	3.4	Clear Fork, Per	DL-S	P	2,900	20			
70				39		Palo Pinto, Pen	L	P	3,557	26	N	Palo Pinto	
71				27		Grayburg, Per	DL	P	2,050	20	A		3,085
72				27	1.4	Clear Fork, Per	D	P	2,450	50	A	Wichita	4,220
73						Clear Fork, Per	D	P	2,450		A	Wichita	4,220
74				38		San Angelo, Per	S	P	1,370	10	ML	Wichita	3,972
75				24		San Andres, Per	D	P	2,040	4		San Andres	2,550
76				36		Grayburg, Per	D	P	4,125	25	A	San Andres	4,610
77				32	2.1	San Andres, Per	D	P	3,500	20	A	San Andres	4,038
78	1,450		G-W	35	1.5	Yates, Per	DS	P	2,825	40	A	Grayburg	3,414
79	4,643			43		Ellenburger, Ord	D	Frac.	10,460	245	A	Ellenburger	10,774
80				36		Grayburg, Per	S-D	P	3,215		A	Ellenburger	10,774
81	4,252			43		Ellenburger, Ord	D	Frac.	9,217		A	Pre-Cambrian	10,005
82	2,160	2,017		39		San Angelo, Per	D	P	4,705		A	Pre-Cambrian	10,005
83	1,573			36	0.8	San Andres, Per	D-S	P	3,200		A	Pre-Cambrian	10,005
84				28	1.6	Yates, Seven Rivers, Per	OD	P	3,000		A	San Andres	3,780
85				34		Seven Rivers, Per	S	P	1,675	10	A	Grayburg	1,995
86				35		Delaware, Per	S	P	4,979			Delaware	4,994
87				30		San Andres, Per	D	P	2,012	10		San Andres	2,150
88				28		Clear Fork, Per	D	P	4,870			Clear Fork	5,002
89	1,905	1,905		31		Grayburg, Per	D	P	4,640			Grayburg	4,807
90				32		Yates, Seven Rivers, Per	S-D	P	2,878	30	A	Seven Rivers	3,175
91	1,445	1,356		28		Seven Rivers, Per	OD	P	2,890	15	A	Queen	3,277
92				39		Delaware, Per	S	P	3,930	10	T	Delaware	4,165
93				28	1.4	Queen, Per	S	P	1,200	5	M	Pre-Cambrian	4,526
94	1,701			22		Clear Fork, Per	D	Fis	3,542		A	Ellenburger	4,700
95				28	2.2	Grayburg, Per	DL	P	2,100	30	A	Ellenburger	8,358
96	750			30	2.4	Grayburg, Per	D	Cav	2,800	40	A	Ellenburger	12,787
97	2,681	975		43		Simpson, Ord	S	Fair	6,106	8	A	Ellenburger	7,204
98				41		Graham, Pen	S	P	2,550	12	N		
99									3,522		N		
100	1,900	1,432		30	2.4	San Andres, Per	D	P	4,475	25	A	San Andres	5,227
101													
102	4,700	4,452		47		Ellenburger, Ord	D	Cav	10,385		A	Ellenburger	10,545
103	2,659	2,659		37		Clear Fork, Per	D	P	6,005		A	Clear Fork	6,399
104	2,340			34	0.8	Clear Fork, Per	D	P	5,635	20	A	Ellenburger	10,545
105				29		Delaware, Per	S	P	4,670	5	T	Delaware	4,692
106				28	2.3	Grayburg, Per	DL	P	3,200	3		Grayburg	3,205
107				25		Grayburg, Per	DL	P	3,200			San Andres	3,516
108				34		Yates, Per	S	P	1,300	15	A	San Andres	2,550
109				32		Yates, Seven Rivers, Per	S	P	{ 992 1,802 }		NC	San Andres	2,039
110	1,740		G	32	1.7	Grayburg, Per	DS	10.2	4,000	65	A	San Andres	5,200

TABLE I.—(*Continued*)

Line Number	Field,[1] County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c] To End of 1944	Oil Production: Total Production, Bbl.[c] During 1944	Gas Production[2]: Area Proved, Acres[d]	Gas Production[2]: Millions Cu. Ft.[e] To End of 1944	Gas Production[2]: Millions Cu. Ft.[e] During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944 Completed	Number of Oil and/or Gas Wells[f]: 1944 Abandoned	Wells Producing[g] Dec. 1944: Oil, Flowing	Wells Producing[g] Dec. 1944: Oil, Artificial Lift	Wells Producing[g] Dec. 1944: Gas
111	North Cowden, Deep, *Ector*	1939	800	178,516	33,918			22	6	1	0	4	2	0
112	North Goldsmith, *Ector*	1936	640	155,253	24,393		1,345	78	12	0	0	7	2	1
113	North Ward, *Ward*	1929	10,000	30,445,558	3,215,873		108,331	10,522	472	47	0	247	203	2
114	Olson, *Crockett*	1940	640	73,749	46,744				15	10	0	0	14	1
115	Ownby, *Yoakum*	1941	1,500	292,370	168,719		251	152	25	15	0	19	6	0
116	Page,* *Schleicher*	1934	4,480	57,167	8,263				7	1	0	1	0	6
117	Parker, *Andrews*	1935	80	109,268	9,984				2	0	0	0	2	0
118	Payton, *Pecos and Ward*	1937	2,000	3,421,838	251,610			274	143	1	3	15	113	0
119	Pecos Valley H. G., *Pecos and Ward*	1928	1,300	1,938,515	128,934				105	2	10	33	56	0
120	Pecos Valley L. G., *Pecos*	1928	2,160	1,190,766	82,132				78	0	4	12	52	0
121	Penwell, *Ector*	1930	6,200	25,396,688	1,189,567		34,408	1,849	176	0	0	67	100	2
122	P. H. D., *Garza*	1944	640	262	262				1	1	0	0	1	0
123	Pruitt, *Ward*	1942	40	3,072	92				1	0	0	0	1	0
124	Pyote, *Ward*	1942	80	82,014	33,743				2	0	0	2	0	0
125	Rhodes,[12] *Cochran*	1941	80	28,649	21,237				8[12]	6	0	0	1	0
126	Richards, *Pecos*	1929	160	31,707	1,004				3	0	1	0	2	0
127	Robertson, *Gaines*	1942	160	27,947	10,882		11	4	1	0	0	1	0	0
128	Russell, *Gaines*	1943	480	139,820	100,395		59	46	6	4	0	5	1	0
129	Sand Hills McKnight,[13,14] *Crane*	1935	600	45,541	45,541			57	9[13]	6	0	5[14]	3	0
130	Sand Hills Ordovician[15] *Crane*													
	Simpson	1936	80	2,089,147	529,038		1,857	439	2	0	0	2	0	0
	Ellenburger	1936	2,000						36	5	0	32	2	0
131	Sand Hills Tubb,[13,14] *Crane*	1934	10,000	7,380,747	2,265,541		11,227	3,679	202[13]	42	0	167[14]	28	5
132	Sand Hills, West, *Crane*	1943	100	6,019	3,860		6	5	2	0	0	0	2	0
133	Scarborough, *Winkler*	1927	2,000	7,797,131	329,731			943	138	0	4	43	78	1
134	Seminole, *Gaines*	1937	13,200	16,974,881	8,777,396		13,835	7,077	326	22	1	310	15	0
135	Shannon, *Crockett*	1943	640	3,281	3,281				8	7	0	0	3	0
136	Sharon Ridge, 1700 ft., *Mitchell and Scurry*[17]	1924	3,800	13,465	13,465[17]				73	1	2	0	67	0
137	Sharon Ridge, Deep, *Scurry*	1938	3,400	2,053,418	332,555				119	5	1	8	110	0
138	Shearer, *Pecos*	1938	480	1,484,851	116,443			71	48	0	0	5	41	0
139	Shipley, *Ward*	1928	2,700	6,656,202	516,489			103	147	1	0	11	124	4
140	Shipley, Silurian, *Ward*	1940	400	54,848	9,872		684	52	2	0	0	2	0	0
141	Slaughter, *Cochran, Hockley and Terry*	1936	70,000	48,859,435	23,080,682		31,305	15,429	1,887	385	0	1,591	270	1
142	Smyer, *Hockley*	1944	200	19,667	19,667				3	2	0	1	2	0
143	Snyder, *Howard*	1935	1,740	2,740,587	188,018				102	1	3	0	98	0
144	South Cowden, *Ector*	1933	4,640	5,044,550	1,431,274			1,395	127	3	0	64	60	0
145	South Ward, *Ward*	1930	10,500	28,734,897	729,781				702	1	25	74	461	5
146	Spencer, *Ward*	1941	400	203,513	75,316		229	41	10	0	0	3	7	0
		1943	40						1	0	0	1	0	0
147	Taylor Link, *Pecos*	1929	2,500	8,756,604	507,941				148	4	1	17	119	0
148	Tobarg, *Pecos*	1928	1,320	8,359,836	478,733				262	2	0	0	259	0
149	Todd, Deep, *Crockett*	1940	1,600	419,702	137,408				20	6	0	20	0	0
150	T. X. L., *Ector*	1944	3,000	400	400				1	1	0	1	0	0
151	Union, *Andrews*	1943	1,360	292,086	283,418		91	89	11	10	0	10	0	0
152	Vincent, *Howard*	1943	120	13,558	8,984				2	1	0	0	2	0
153	Vincent 5500 ft., *Howard*	1944	80						1	1	0	0	1	0
154	Waddell, *Crane*	1927	4,000	6,490,049	1,607,014		3,750	1,016	105	15	0	89	12	3
155	Walker, *Pecos*	1940	1,800	1,147,177	399,116			236	75	3	0	57	17	0
156	Waples Platter, *Yoakum*	1939	800	150,964	54,210			46	16	9	0	1	13	0
157	Wasson, *Gaines and Yoakum*	1936	57,000	78,674,433	23,725,906		81,777	24,146	1,512	59	3	1,359	144	0
158	Wasson, 66,[16] *Gaines*	1940	1,440	118,045	63,263		69	37	6[15]	5	0	5	0	0
159	Wasson 72,[16] *Gaines*	1941	1,360	112,439	62,611		62	41	7[15]	6	0	7	0	0
160	Webb Ray, *Upton*	1935	160	72,499	1,490				6	0	1	0	1	0
161	Weiner, *Winkler*	1941	2,500	897,207	543,634			700	55	16	0	49	5	1
162	Welch, *Dawson*	1941	160	27,831	9,002				1	1	0	0	1	0

[12] Six wells transferred from Rhodes to Slaughter.
[13] Three wells transferred from Sand Hills Permian to Sand Hills McKnight.
[14] Sand Hills McKnight and Tubb, three dual completions.
[15] Four Areas of Ordovician production.
[16] Wasson 66 and 72, four dual completions.
[17] Sharon Ridge, 1700 ft. 2 months production.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Secondary Recovery[h]	Character of Oil[i]		Producing Formation						Deepest Zone Tested[p] to End of 1944	
	Initial	Avg./End 1944		Gravity A.P.I. at 60°F.	Sulphur, Per Cent	Name and Age[j]	Character[k]	Porosity, Per Cent[l]	Depth to Top of Producing Zone, Ft.[m]	Productive Thickness Avg. Ft.,[n] Net	Structure[o]	Name	Depth of Hole, Ft.
111	1,300			31	1.0	San Andres, Per	L	11	5,100	15	A	Pennsylvanian	10,829
112		847		36	2.0	San Andres, Per	DL	P	4,315	18	A	Clear Fork	6,499
113	1,400		G	36	1.8	Seven Rivers, Per	D-S	P	2,500	40	ML	San Andres	4,825
114				25		San Andres, Per	D	P	2,111	15	A	San Andres	2,371
115	1,638	1,327		31		San Andres, Per	D	P	5,235	27	A	San Andres	5,700
116				38		Strawn, Pen	L	20	5,730	65	A	Ellenburger	7,011
117				29		San Andres, Per	D	15	4,625	5	MC	San Andres	4,806
118			G	33	1.1	Yates, Per	S	P	2,000	40	A	San Andres	3,200
119			G	38	1.1	Yates, Per	S	P	1,875	15	A	San Andres	2,253
120				25	1.7	Yates, Per	S	P	1,500	15	A	Ellenburger	5,665
121	1,375	716		35	2.6	San Andres, Per	D	P	3,550	30	A	San Andres	4,002
122	1,185	1,185		38		San Andres, Per	D	P	3,544		A	San Andres	3,768
123						Delaware, Per	S	P	4,831		A	Delaware	4,869
124	1,430			20	1.8	Yates, Seven Rivers, Per	D	8	2,827	9.5	A	Seven Rivers	3,100
125				29		San Andres, Per	D	P	5,050	41	MC	San Andres	5,150
126				17		Dewey Lake, Per	S	P	1,380	10		San Andres	4,360
127	2,137			26		San Angelo, Per	D	P	5,910	42	A	Clear Fork	7,686
128	2,420			29	1.4	Clear Fork, Per	D	P	7,443	20	A	Clear Fork	7,770
129	1,511	1,472		35		San Andres, Per	D	P	3,200		A	Ellenburger	6,010
130	2,740			37		Simpson, Ord Ellenburger, Ord	S D	P Frac.	5,550 5,900	20 20	AF AF	Pre-Cambrian Pre-Cambrian	7,158 7,158
131	2,200	1,388		35		Clear Fork, Per	D	P	4,250	40	A	Pre-Cambrian	7,158
132						San Andres, Per	D	P	3,800	15		Ellenburger	7,777
133			G	35	1.0	Yates, Per	S-D	P	2,800	10	A	Grayburg	3,565
134	2,025	1,761		35	1.8	San Andres, Per	D	P	5,000	90	A	Wolfcamp	9,312
135				28		San Andres, Per	D	P	2,158			San Andres	2,467
136				29		San Andres, Per	DL	P	1,700		A	Wolfcamp	4,524
137				30		San Angelo, Clear Fork, Per	D-S	P	2,400 3,250		A	Wichita	3,545
138				35		Seven Rivers, Per	S	P	1,415			Pre-Cambrian	4,526
139				35	1.8	Seven Rivers, Queen, Per	DS	P	2,480 3,000	60	A	Ellenburger	9,187
140	3,281			32		Sil	L	P	7,000	50		Ellenburger	9,187
141	1,775	1,472		32	1.9	San Andres, Per	D	P	4,950	32	MC	Clear Fork	7,000
142				25		Clear Fork, Per	D	P	5,850			Clear Fork	6,000
143				30	1.7	San Angelo, Per	DL	P	2,650	50	A	Clear Fork	3,750
144	1,740			34	1.7	Grayburg, Per	DS	11	4,000	42	A	San Andres	5,500
145	1,370			32	1.3	Seven Rivers, Per	S	P	2,300	40	ML	Wichita (?)	4,825
146	1,430 960			28 30	0.6 1.6	Seven Rivers, Per Yates, Per	OD S-D	8 P	2,926 2,765	20 8	A A	Seven Rivers Seven Rivers	3,000 3,000
147	700			29	1.3	Yates, Queen, San Andres, Per	D-S	P	1,580	25	A	San Andres	1,845
148	108			19	1.9	Tobarg, Cre	S	P	400	15	AL	San Andres	1,400
149	2,600			42		Strawn, Pen	L	P	5,789	100	A	Ellenburger	7,143
150				41		Lower Dev	Ch	Frac.	7,886		A	Ellenburger	10,181
151	3,000			44		Wichita, Per	D	P	6,900	120	A	Wichita	7,459
152				27		Clear Fork, Per	P	P	4,040		A	Wolfcamp	6,172
153				33		Wichita, Per			5,450		A	Wolfcamp	6,172
154	1,550			36	2.1	San Andres, Per	D	P	3,450	20	A	Clear Fork	3,622
155				30	1.4	Queen, Per	S	20	1,950	25	A	San Andres	2,136
156	1,465	1,004		32		San Andres, Per	D	P	5,200	25	A	San Andres	5,380
157	1,850	1,454		34	1.6	San Andres, Per	D	P	4,900	50	AM		11,108
158				32	1.4	Clear Fork, Per	D	P	6,210				11,108
159				35	1.0	Clear Fork, Per	D	P	7,055				11,108
160				25		Grayburg, Per	DL	P	2,060	20	A	San Andres	2,176
161	1,270	1,069		33		Queen, Per	S	P	3,025	40	A	San Andres	3,896
162				33		San Andres, Per	D	P	4,918		A	San Andres	4,986

In order to handle sweet crude exclusively in the 8-in. line from the Fullerton field to Midland, the Magnolia Pipe Line Co. decreased the capacity by transfer of pumping equipment to its new 12-in. line from Midland to Corsicana, Texas. The 12-in. line was placed in operation in February 1944. In March 1944, the Stanolind Pipe Line Co. began to operate its 16-in. line from Slaughter field to Drumright, Oklahoma. By tank-car shipment from Midland, the Atlantic Pipe Line Co. moved 7,460,439 bbl. of crude to eastern markets. During the last two weeks

TABLE 1.—(*Continued*)

Line Number	Field,[1] County[a]	Year of Discovery	Oil Production: Area Proved, Acres[b]	Oil Production: Total Production, Bbl.[c]: To End of 1944	Oil Production: Total Production, Bbl.[c]: During 1944	Gas Production[2]: Area Proved, Acres[d]	Gas Production[2]: Millions Cu. Ft.[e]: To End of 1944	Gas Production[2]: Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells[f]: Completed to End of 1944	Number of Oil and/or Gas Wells[f]: 1944: Completed	Number of Oil and/or Gas Wells[f]: 1944: Abandoned	Wells Producing[g] Dec. 1944: Oil: Flowing	Wells Producing[g] Dec. 1944: Oil: Artificial Lift	Wells Producing[g] Dec. 1944: Gas
163	Wentz, *Pecos*	1941	640	68,442	22,280		99	18	2	0	0	0	2	0
164	West, *Yoakum*	1938	40	57,294	7,425				1	0	0	0	1	0
165	West Andrews, *Andrews*	1940	1,000	134,060	23,507			39	23	0	0	5	13	2
166	Westbrook, *Mitchell*	1921	6,300	10,123,027	493,296				208	52	10	0	153	0
167	Wheat, *Loving*	1925	4,060	9,482,959	275,074			154	116	0	3	30	54	0
168	Wheeler Ellenburger, *Winkler*	1943	1,960	345,779	305,192		481	425	8	7	0	8	0	0
169	White and Baker, *Pecos*	1935	1,600	502,685	132,650		396	173	39	5	0	31	1	7
170	White and Baker Lime, *Pecos*	1943	300	10,385	8,526				1	0	0	1	0	0
171	Winters, *Runnels*	1943	80	10,488	4,006				2	0	0	0	1	0
172	World, *Crockett*	1925	3,000	9,136,239	717,283				114	3	0	0	90	0
173	Wyatt, *Crockett*	1932	160	47,369	6,677				4	0	0	1	0	0
174	Yates, *Crockett and Pecos*	1926	20,000	287,827,341	12,639,114		124,431	2,294	573	13	1	513	54	1
175	Yates Sand, *Pecos*	1933	700	586,102	41,908				10	0	0	1	9	0
176	Yellowhouse, *Hockley*	1944		14,849	14,849				2	2	0	0	2	0

Line Number	Reservoir Pressure, Lb. per Sq. In.: Initial	Reservoir Pressure, Lb. per Sq. In.: Avg./End 1944	Secondary Recovery[h]	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur, Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness Avg. Ft.,[n] Net	Producing Formation: Structure[o]	Deepest Zone Tested[p] to End of 1944: Name	Deepest Zone Tested[p] to End of 1944: Depth of Hole, Ft.
163	1,399			33		Ellenburger, Ord	D-S	P	4,300	20		Pre-Cambrian	4,493
164				31		San Andres, Per	D	P	5,168	10	MC	San Andres	5,255
165				36		San Andres, Per	D	7	4,300	25	A	Ellenburger	8,368
166				23	3.9	Clear Fork, Per	D	P	2,800	50	MC	Ellenburger	8,201
167				38		Delaware, Per	S	P	4,290	7	MC	Delaware	5,083
168	4,583	4,562		45		Ellenburger, Ord	L	P	10,493	55	A	Ellenburger	10,697
169	800			30		Queen, Per	S	20	1,700	30	A	Lower Ordovician	9,811
170	750			29		San Andres, Per	L	P	1,704	45	A	Lower Ordovician	9,811
171				42		Cisco, Pen	S	P	2,464			Ellenburger	4,735
172				29	0.7	San Andres, Per	D	P	2,415	13	A	San Andres	3,695
173	555			23	0.7	San Andres, Per	D	10	1,217	5	A	Ellenburger	7,010
174	700	517		30	1.6	San Andres, Per	D	P	1,310	100	A	Ellenburger	9,114
175				32	1.5	Yates, Per	S	P	900	15	AL	Ellenburger	9,114
176	1,507	1,507		27		San Andres, Per	D	P	4,596	15		San Andres	4,685

TABLE 2.—*Summary of Drilling Operations in West Texas*

Important Wildcats Drilled in 1944

	County	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
		Sec.	Block	Survey			
1	Andrews	5	11	Univ.	8,536	Tertiary to Recent	Devonian
2	Andrews	10	14	Univ.	6,942	Tertiary to Recent	Clear Fork
3	Andrews	23	A-46	P.S.L.	11,812	Tertiary to Recent	Ordovician
4	Andrews	7	A-40	P.S.L.	10,929	Tertiary to Recent	Pre-Cambrian
5	Andrews	20	13	Univ.	8,955	Tertiary to Recent	Devonian
6	Andrews	111	P	J. Harballis	7,810	Tertiary to Recent	Wichita
7	Andrews	37	9	Univ.	4,717	Tertiary to Recent	Grayburg
8	Andrews	5	A-31	P.S.L.	11,061	Tertiary to Recent	Pre-Cambrian
9	Andrews	25	A-35	P.S.L.	4,628	Tertiary to Recent	San Andres
10	Andrews	14	73	P.S.L.	11,322	Tertiary to Recent	Pre-Cambrian
11	Andrews	1	42	G. & M. M. B. & A.	4,942	Tertiary to Recent	Grayburg
12	Andrews	17	A-35	P.S.L.	4,562	Tertiary to Recent	San Andres
13	Andrews	21	A-36	P.S.L.	6,242	Tertiary to Recent	Clear Fork
14	Andrews	22	A-36	P.S.L.	4,414	Tertiary to Recent	San Andres
15	Andrews	41	9	Univ.	5,520	Tertiary to Recent	San Angelo
16	Brewster	66	10	G. H. & S. A.	9,046	Comanchean	Ellenburger
17	Cochran	Lab. 9	Lge. 64	Midland County School Lands	4,952	Tertiary	San Andres
18	Cochran	Lab. 18	Lge. 94	Mills County School Lands	5,035	Tertiary	San Andres
19	Cochran	Lab. 19	Lge. 97	Brewster County School Lands	4,925	Tertiary	San Andres
20	Cochran	Lab. 18	Lge. 62	Midland County School Lands	4,875	Tertiary	San Andres
21	Crane	8	B-28	P.S.L.	7,891	Recent	Ellenburger
22	Crane	20	26	P.S.L.	5,881	Recent	Ellenburger
23	Crane	27	26	P.S.L.	3,230	Recent	San Andres
24	Crane	6	1	H. & T. C.	6,185	Recent	Ellenburger
25	Crane	20	3	H. & T. C.	6,181	Recent	Ellenburger
26	Crane	42	32	P.S.L.	4,651	Recent	Clear Fork
27	Crane	7	B-26	P.S.L.	4,757	Recent	Clear Fork
28	Crane	46	35	H. & T. C.	6,021	Comanchean	Simpson
29	Crockett	25	"WX"	G. C. & S. F.	6,285	Comanchean	Ellenburger
30	Crockett	5	"GG"	H. & O. B.	1,526	Comanchean	Yates
31	Crockett	46	"BB"	I. C. R. R.	9,916	Comanchean	Ellenburger
32	Crockett	24	1	G. C. & S. F.	2,215	Comanchean	San Andres
33	Crockett	73	1	I. & G. N.	7,640	Comanchean	Ellenburger
34	Culberson	33	62	P.S.L.	5,417	Capitan	Bliss
35	Culberson	16	54	P.S.L.	7,005	Recent	Delaware
36	Dawson	30	1	J. Poitevant	10,455	Tertiary	Pennsylvanian
37	Dawson	38	34	T-5-N T. & P.	7,625	Tertairy	Clear Fork
38	Dickens	10	"A.S."	J. S. Callaway	6,987	Whitehorse	Pennsylvanian
39	Ector	9	42	T-2-S T. & P.	4,450	Tertiary	Grayburg
40	Ector	7	45	T-1-S T. & P.	10,181	Comanchean	Ellenburger
41	Ector	12	44	T-1-N T. & P.	10,829	Tertiary	Pennsylvanian
42	Gaines	59	"AX"	P.S.L.	7,838	Tertiary	Clear Fork
43	Gaines	22	A-7	P.S.L.	12,222	Tertiary	Devonian
44	Gaines	96	"G"	W. & T. R. R.	5,457	Tertiary	San Andres
45	Gaines	14	A-11	P.S.L.	11,651	Tertiary	Devonian
46	Gaines	9	A-24	P.S.L.	9,049	Tertiary	Wolfcamp
47	Garza	1,421		T. T. R. R.	3,768	Tertiary	San Andres

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1944

	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
		Oil, U. S. Bbl.	Gas Millions Cu. Ft.		Casing	Tubing	
1	Champlin Ref. Co.						Dry and abandoned
2	Cities Service Oil Co.		7.734		Shut in 1940		Extension Shafter Lake Gas field
3	Humble Oil & Ref. Co.						Dry and abandoned (Deep Rock field)
4	Humble Oil & Ref. Co.						Dry and abandoned
5	Mid Continent Petr. Co.	3,744	G.O.R. 342	¾″ tbg. ch.	800–700	800–425	Discovery Fullerton 8500-ft. field
6	N. G. Penrose Inc. et al.						Dry and abandoned (Mascho field)
7	Phillips Petr. Co. et al.	Pump { 121 bbl. oil, 16 bbl. water					Extension North Cowden field
8	Shell Oil Co. Inc.						Dry and abandoned
9	Signal Oil & Gas Co.	Pump { 19 bbl. oil, 5 bbl. water		2″ tbg.			Extension Means field
10	Sinclair-Prairie Oil Co.						Dry and abandoned
11	Stanolind Oil & Gas Co.	Pump { 548 bbl. oil, 41 bbl. water		2½″ tbg.			Discovery Midland Farms field
12	Sun Oil Co.	232		29/64″ tbg. ch.	0–40	325–60	Extension Means field
13	Texas Company	Pump { 154 bbl. oil, 34 bbl. water	G.O.R. 407	2″ tbg.			Extension Deep Rock field
14	Texas Company	Pump 72	G.O.R. 483	2″ tbg.			Extension Deep Rock field
15	Texas Company	541 Cut 8% sulphur water		Open 2″ tbg.	300	300	Extension Clabberhill field
16	W. B. Hinton						Dry and abandoned
17	E. Constantine, Jr.	Pump { 253 bbl. oil, 67% water	G.O.R. 130	2″ tbg.			Extension Slaughter field
18	Falcon Oil Co.	Pump { 68 bbl. oil, 28 bbl. water		2″ tbg.			Extension Slaughter field
19	Helmerich & Payne Inc.	Pump 369		2½″ tbg.			Extension Slaughter field
20	San Andres Prod. Co.	Pump 187	G.O.R. 600	2″ tbg.			Extension Slaughter field
21	Gulf Oil Corp.						Dry and abandoned
22	Gulf Oil Corp.	1,275	G.O.R. 440	Open tbg. & csg.			Discovery N.E. Sand Hills Ordovician field
23	Gulf Oil Corp.	11,741	G.O.R. 975	Open tbg. & csg.	1,400–90	550–88	Discovery commercial prod. Sand Hills McKnight field
24	Magnolia Petr. Co.						Dry and abandoned
25	Magnolia Petr. Co.						Dry and abandoned
26	J. I. Moore	Pump 191		2″ tbg.			Extension Sand Hills Tubb field (Barnsley field)
27	Schermerhorn Oil Corp.	207	G.O.R. 1,627	¾″ tbg. ch.	920	350	Extension Sand Hills Tubb field
28	Texas Company	434	G.O.R. 1,900	1″ tbg. ch.	825–375	30	Discovery Crossett field
29	Amerada Petr. Corp.	312	G.O.R. 708	1″ tbg. ch.			Discovery Todd Ellenburger field
30	E. J. McCurdy		4.5				Discovery Clara Couch Gas field
31	Phillips Petr. Co.						Dry and abandoned
32	Standard Oil Co. of Ohio	Pump { 66 bbl. oil, 30% water		2″ tbg.			Extension Shannon field
33	Watchorn Oil & Gas Co.						Dry and abandoned
34	Humble Oil & Ref. Co.						Dry and abandoned
35	Standard Oil Co. of Texas						Dry and abandoned
36	Gulf Oil Corp.						Temporarily abandoned
37	Seaboard Oil Co.						Dry and abandoned
38	Humble Oil & Ref. Co.						Junked and abandoned
39	M. B. K. Drilling Co.	Pump 279	G.O.R. 179	2″ tbg.			Extension Foster field
40	Shell & Cities Service Oil Co.	1,911	G.O.R. 873	½″ tbg. ch.	0	50	Discovery T.X.L. field
41	Stanolind Oil & Gas Co.						Dry and abandoned, North Cowden Deep field
42	Amerada Petr. Corp.						Dry and abandoned
43	Continental Oil Co.						Dry and abandoned
44	Honolulu Oil Corp.		5.512	Csg. flow			Discovery Homann gas field
45	Humble Oil & Ref. Co.						Dry and abandoned
46	Humble Oil & Ref. Co.	210	G.O.R. 517	¼″ tbg. ch.	600–260	460–180	Discovery Doss field
47	Honolulu & Devonian Oil Co.	Pump { 131 bbl. oil, 30 bbl. water	G.O.R. 360	2½″ tbg.			Discovery P.H.D. field

in December, the company shipped 9917 bbl. to the West coast. Since then shipments have been increased to approximately 65 cars per day.

Adjustments in Price of Crude

Because sweet crude was produced from the fields shown in Table 12, new prices for crude have been posted by the purchasing companies. The stripper fields that have been granted a subsidy price increase are shown in Table 12.

Secondary Recovery

Not enough field data have yet been collected to determine the effectiveness of gas and water injection. Some gas is being injected in the North Cowden, Payton, Pecos Valley high-gravity, North Ward, Kermit and Scarborough fields. Water is being injected in the Estes and Kermit fields. As most of the wells in these fields were shot with nitroglycerin at the time of completion, it is difficult to restrict the input fluids to the less permeable parts of the pay section to prevent bypassing. While the initial shooting with nitroglycerin increased well potentials for competitive proration purposes, it is questionable whether the practice increased the ultimate recovery as much as might

Table 2.—(*Continued*)

Important Wildcats Drilled in 1944

	County	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
		Sec.	Block	Survey			
48	Glasscock	9	36	T-3-S T. & P.	6,008	Tertiary	San Andres
49	Hockley	Lab. 103E	Lge. 75	Haskell County School Lands	4,685	Tertiary	San Andres
50	Howard	57	20	Lavoca Navigation Co.	6,172	Triassic	Wolfcamp
51	Howard	20	30	T-1-S T. & P.	3,051	Triassic	Clear Fork
52	Howard	23	34	T-1-N T. & P.	3,516	Tertiary	San Andres
53	Irion	12		G. C. & S. F.	8,357	Comanchean	Pre-Cambrian
54	Lynn	1,372	1	B. S. & F.	9,909	Tertiary	Pre-Cambrian
55	Lynn	113	12	E. I. & R. R.	7,142	Tertiary	Clear Fork
56	Midland	36	39	T-3-S T. & P.	6,125	Tertiary	San Andres
57	Mitchell	22	28	T-1-N T. & P.	8,201	Whitehorse	Ellenburger
58	Mitchell	22	27	T-1-N T. & P.	7,875	Whitehorse	Ellenburger
59	Mitchell	19	17	S. P. R. R.	8,125	Whitehorse	Ellenburger
60	Pecos	13	194	G. C. & S. F.	1,920	Comanchean	San Andres
61	Pecos	61	10	H. & G. N.	1,477	Comanchean	Seven Rivers
62	Pecos	7	140	T. & St.	8,440	Comanchean	Ellenburger
63	Pecos	3	114	G. C. & S. F.	3,604	Comanchean	Seven Rivers
64	Pecos	4	5	T. C. R. R.	9,150	Comanchean	Wolfcamp
65	Pecos	1	20	Univ.	7,384	Comanchean	Ellenburger
66	Pecos	36	144	T. & St. L.R.R.	5,313	Comanchean	Pre-Cambrian
67	Pecos	4	228	W. & N. W.	5,020	Comanchean	Pre-Cambrian
68	Pecos	27	8	H. & G. N.	8,232	Tertiary gravel	Bone Springs
69	Reagan	10	2	Univ.	10,072	Comanchean	Ellenburger
70	Reagan	25	8	Univ.	3,175	Comanchean	Ellenburger
71	Reeves	10	72	P. S. L.	8,894	Recent gravel	Bone Springs
72	Schleicher	24	"L"	G. H. & S. A.	5,702	Comanchean	Pennsylvanian
73	Ward	25	B-18	P. S. L.	9,669	Recent	Ellenburger
74	Ward	43	18	Univ.	4,994	Recent	Delaware
75	Winkler	4	B-3	P. S. L.	10,680	Recent	Ellenburger
76	Winkler	11	B-5	P. S. L.	12,305	Recent	Ellenburger
77	Winkler	50	"A"	G. & M. M. B. & A.	6,305	Recent	Clear Fork
78	Winkler	24	B-10	P. S. L.	6,287	Recent	Clear Fork
79	Yoakum	446	"D"	J. H. Gibson	7,717	Tertiary	Clear Fork
80	Yoakum	635	"D"	J. H. Gibson	5,340	Tertiary	San Andres

be obtainable with secondary recovery methods using unshot boreholes. Shooting precludes effective remedial work to control water encroachment and increasing gas-oil ratios.

Engineering committees are studying reservoir conditions to determine the advisability of gas or water injection to arrest pressure decline in the Seminole, Slaughter, Colby, Goldsmith, and Fullerton fields.

Discoveries and Extensions

Prior to 1944, the most notable characteristic of the Devonian formation was the chert concentration, which greatly retarded drilling to the underlying productive formations. As a result of wildcat drilling,

Table 2.—(*Continued*)

Important Wildcats Drilled in 1944

	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
		Oil, U. S. Bbl.	Gas Millions Cu. Ft.		Casing	Tubing	
48	Richfield Oil Corp.						Dry and abandoned
49	Stanolind Oil & Gas Co.	Pump { 61 bbl. oil, 19 bbl. water		2″ tbg.			Discovery Yellowhouse field
50	W. S. Guthrie & Cosden Petr. Corp. No. 2	Pump 36	G.O.R. 500	2″ tbg.			Discovery Vincent 5500-ft. field
51	L. C. Harrison.........	Pump 45		2″ tbg.			Extension Iatan-East Howard field
52	J. B. Hawley, Jr.	Pump { 13 bbl. oil, 7 bbl. water		2″ tbg.			Extension Morita field
53	Shell Oil Co. Inc.						Dry and abandoned
54	Phillips Petr. Co.						Dry and abandoned
55	Sohio						Dry and abandoned
56	Barnsdall Oil Co.						Dry and abandoned
57	Col Tex Ref. Co.						Dry and abandoned
58	Humble Oil & Ref. Co.						Dry and abandoned
59	Shamrock Oil & Gas Co.						Dry and abandoned
60	James T. Brewer	168	G.O.R. 450	Open 2″ tbg.	0	80	Extension Yates field
61	Burke Royalty Co.	24 bbl. oil. 7 bbl. water		tbg.	0	70	Discovery Debs? field
62	Humble Oil & Ref. Co.						Dry and abandoned
63	Humble Oil & Ref. Co.	22	G.O.R. 1,650	19/64″ tbg. ch.	460–320	0–50	Discovery Fort Stockton field
64	Humble Oil & Ref. Co.						Dry and abandoned
65	Phillips Petr. Co.						Dry and abandoned
66	Standard Oil Co. of Texas		17.3	7″ csg.	Shut in 1925	Flowing 1,350	Discovery Mac Der gas field
67	Standard Oil Co. of Texas		1.5				Extension Mac Der gas field
68	Standard Oil Co. of Texas						Dry and abandoned
69	Big Lake Oil Co.						Dry and abandoned
70	Superior Oil Co. & Wiggins & Hyde	Pump { 61 bbl. oil, 114 bbl. water		tbg.			Extension Grayson field
71	Standard Oil Co. of Texas		12.0				Dry and abandoned
72	Globe Oil & Ref. Co.						Extension Page gas field
73	Gulf Oil Corp.						Dry and abandoned
74	Lion Oil Ref. Co.	122	G.O.R. 825	24/64″ tbg. ch.	Packer	850	Discovery Lion field
75	Magnolia Petr. Corp.	{ 106 bbl. oil, 64% water	G.O.R. 5,488	3/16″ tbg. ch.	3,125	1,850–3,125	Extension Kermit Ellenburger field
76	Sinclair-Prairie Oil Co.						Dry and abandoned
77	Stanolind Oil & Gas Co.	298	G.O.R. 2,998	8/64″ tbg. ch.	800	600	Discovery North Monahans field
78	Texas Company	563	G.O.R. 1,259	23/64″ tbg. ch.	975	450	Extension North Monahans field
79	Skelly Oil Co.						Dry and abandoned
80	Woodley Petr. Co.	Pump 134		2″ tbg.			Extension Wasson field

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1944..................	270	91
Number of oil wells completed during 1944..................	1,325	36
Number of gas wells completed during 1944..................	10	6
Number of dry holes completed during 1944..................	102	167

TABLE 3.—*Number of Wells Completed in West Texas during* 1941–1944

Year	1941	1942	1943	1944
Field wells:				
Oil		1,052	732	1,325
Gas		69	5	10
Dry		10	59	102
Total	2,190	1,131	796	1,437
Wildcat wells:				
Oil	25	36	23	36
Gas		1	3	6
Dry		99	80	167
Total	135	136	106	209
Total wells drilled:				
Oil		1,088	755	1,361
Gas		11	8	16
Dry		168	139	269
Total	2,325	1,267	902	1,646
Wildcat percentage of total number of wells drilled	5.8	10.7	11.7	12.7

TABLE 4.—*Distribution of Wildcat Oil Wells, West Texas*

Year	1941	1942	1943	1944
New field discoveries		16	12	10
New productive horizons in old fields		3	7	5
Extensions to established fields		17	4	21
Total oil wells		36	23	36
Total wildcat wells		136	106	209
Percentage wildcat wells completed as oil wells	20.0	26.5	21.7	17.2

TABLE 5.—*Production of Crude Oil in West Texas*[a]

1944	Wells: Flow	Wells: Pump	Reported Production, Bbl.	Runs to Pipe Line, Bbl.
January	7922	7758	11,341,986	11,279,812
February	8045	7803	10,616,950	10,652,230
March	8068	7862	10,896,608	10,842,969
April	8078	7962	11,526,309	11,488,631
May	8094	8059	13,504,014	13,461,764
June	8147	8003	13,542,211	13,490,460
July	8196	8108	14,283,308	14,158,338
August	8222	8236	15,006,653	14,988,748
September	8274	8306	15,061,361	15,029,804
October	8249	8409	15,336,462	15,270,796
November	8244	8496	14,249,663	14,156,330
December	8260	8552	14,577,957	14,494,625
Total 1944:			159,943,482	159,314,507
Average Number prod. Wells 1944			16,279	
Average Daily Prod. per Well			26.8	
Total 1943:			98,164,812	97,604,572
Average Number Prod. Wells 1943			15,349	
Average Daily Prod. per Well			17.5	

[a] Compiled from monthly reports of the Railroad Commission of Texas.

three significant Devonian discoveries were made from quite dissimilar pay sections. In the Crossett field, the pay section from 5260 to 5345 ft. consists of a porous calcareous chert and a siliceous finely crystalline limestone. In the Fullerton 8500-ft. field, production is obtained from 8380 to 8600 ft. in a very porous dolomite. In the T. X. L. field, from 7886 to 8020 ft., there is a fractured chert with little evident porosity. The most significant Ellenburger discovery was made in the Todd field. All of these fields have favorable possibilities of development into major oil fields.

TABLE 6.—*Gasoline-plant Production Data, West Texas, for Year* 1944[a]

Plant	Location	Yearly Gas Volume, M Cu. Ft.	Yearly Raw Gasoline, Bbl.	Number Wells Connected
Barnsdall	Foster-S. Cowden	3,623,766	103,923	513
Cabot-Estes	North Ward	8,430,810	275,728	494
Cabot-Walton	Kermit	9,333,000	211,060	643
Cabot-Keystone	Keystone	2,642,276	20,146	111
Cities Service	North Cowden	7,842,282	172,187	361
Gulf Oil Corp.	North Ward	6,197,478	169,845	209
Luce & Ice	Payton-Ward	229,816	570	16
Magnolia	Kermit	1,208,532	17,266	62
Phillips Petr. Co.	Crane	9,130,968	324,964	536
Phillips Petr. Co.	Goldsmith	17,609,724	524,158	903
Phillips Petr. Co.	Penwell	5,254,662	258,404	540
Phillips Petr. Co.	Seminole	3,497,840	181,929	304
Shell Oil Co.	Wasson	10,075,614	399,029	1,255
Standard Oil Co.	So. Ward	4,357,230	138,028	287
Total		89,433,998	2,797,237	6,234

[a] Taken from R. R. Commission Records.

One of the major factors in increasing proven oil reserves was the extension by field development of the Keystone Ellenburger field. While the proven area may not exceed seven thousand acres, the unusually thick pay section assures an exceptionally large yield per acre. On the northeast side of the Sand Hills field, the Gulf Oil Corporation found a third area of Ellenburger production. Because of a thicker pay section, this extension promises a higher yield per acre than that previously developed. The Gulf Oil Corporation also discovered an area of more prolific production in the "Mc-

TABLE 7.—*Distribution Field Well Development, 1944, in West Texas*

County	Field	Number of Oil Wells	Number Oil Wells Drilled Deeper	Number Gas Wells	Number Dry and Abandoned	Total	Estimated Completion Days				Total Footage Drilled					
							Oil	Gas	Dry	Total	Oil	Oil Wells Drilled Deep-	Gas	Dry	1944 Total	1943 Total
Andrews	Clabberhill				1	1			105	105				5,642	5,642	
	Embar	3			1	4	288		108	396	23,703			8,045	31,748	
	Embar Permian	1				1	71			71	6,250				6,250	
	Embar and Embar Permian (dual)	1				1	111			111	7,926				7,926	
	Emma	3			2	5	216		208	424	12,776			10,824	23,600	
	Fuhrman	19				19	1,346			1,346	84,736				84,736	
	Fullerton	116				116	10,888			10,888	829,310				829,310	
	Fullerton 8500 ft.	1				1	117			117	8,658				8,658	
	Mascho	43				43	4,378			4,378	197,863				197,863	
	Mabee	32				32	2,606			2,606	151,326				151,326	
	Means	2	1			3	118			118	9,080	10			9,090	
	Midland Farms	3				3	224			224	14,524				14,524	
	North Cowden	32			1	33	2,052		160	2,212	148,931			4,858	153,789	
	Union	10				10	1,491			1,491	74,807				74,807	
Total		266	1		5	272	23,906		581	24,487	1,569,890	10		29,369	1,599,269	583,298
Cochran	Dean	4				4	253			253	20,278				20,278	
	Rhodes	6				6	372			372	30,463				30,463	
	Slaughter	127	1		11	139	8,606		1,192	9,798	636,066	21		55,091	691,178	
Total		137	1		11	149	9,231		1,192	10,423	686,807	21		55,091	741,919	553,156
Coke	Blackwell				1	1			86	86				6,425	6,425	3,748
Crane	Crossett	2				2	210			210	10,777				10,777	
	Dune	4			2	6	226		78	304	12,730			6,597	19,327	
	McCamey		3		1	4			133	133		187		1,020	1,207	
	McElroy	14	4		1	19	821		62	883	43,140	349		3,615	47,104	
	McKey	1			1	2	189		90	279	6,141			6,240	12,381	
	Sand Hills McKnight	3				3	175			175	11,621				11,621	
	Sand Hills McKnight and Tubb (dual)	3				3	230			230	14,397				14,397	
	Sand Hills Ordovician]	4			1	5	359		133	492	23,665			5,840	29,505	
	Sand Hills Tubb	37				37	2,385			2,385	169,664				169,664	
	Waddell	15				15	1,104			1,104	52,465				52,465	
Total		83	7		6	96	5,699		496	6,195	344,600	536		23,312	368,448	95,538
Crockett	Clara Couch	3			4	7	327		237	564	5,228			8,253	13,481	
	Crockett	3			1	4	192		37	229	4,941			1,170	6,111	
	Noelke	7		2	3	12	389	119	365	873	10,334		3,586	6,342	20,262	
	Olsen	10			1	11	1,666		69	1,735	21,471			2,041	23,512	
	Shannon	6		1	4	11	596	152	205	953	13,512		2,410	7,205	23,127	
	Todd-Deep	6				6	670			670	37,670				37,670	
	World	3	1			4	478			478	7,924	56			7,980	
Total		38	1	3	13	55	4,318	271	913	5,502	101,080	56	5,996	25,011	132,143	63,614

TABLE 7.—(*Continued*)

County	Field	Number of Oil Wells	Number Oil Wells Drilled Deeper	Number Gas Wells	Number Dry and Abandoned	Total	Estimated Completion Days: Oil	Estimated Completion Days: Gas	Estimated Completion Days: Dry	Estimated Completion Days: Total	Total Footage Drilled: Oil	Total Footage Drilled: Oil Wells Drilled Deeper	Total Footage Drilled: Gas	Total Footage Drilled: Dry	Total Footage Drilled: 1944 Total	Total Footage Drilled: 1943 Total
Ector	Foster	1				1	56			56	4,170				4,170	
	Goldsmith	17				17	731			731	72,866				72,866	
	Johnson	1			1	2	61		34	95	4,157			4,814	8,971	
	Jordan	1				1	66			66	3,662				3,662	
	North Cowden	30				30	2,720			2,720	139,485				139,485	
	North Cowden Deep	1				1	83			83	5,152				5,152	
	South Cowden	3			1	4	276		26	302	13,613			4,827	18,440	
Total		54			2	56	3,993		60	4,053	243,105			9,641	252,746	276,231
Gaines	Cedar Lake	3				3	243			243	14,438				14,438	
	Russell	4				4	550			550	31,142				31,142	
	Seminole	22	1		2	25	1,329		114	1,443	115,577	154		10,502	126,233	
	Wasson	13				13	738			738	65,079				65,079	
	Wasson Deep	2				2	428			428	15,129				15,129	
	Wasson "72"	3			1	4	493		123	616	22,364			8,097	30,461	
	Wasson Deep and "72" (dual)	3				3	590			590	22,535				22,535	
Total		50	1		3	54	4,371		237	4,608	286,264	154		18,599	305,017	174,249
Glasscock	Howard Glasscock Total				1	1			16	16				1,420	1,420	3,806
Garsa	Garza	1				1	104			104	2,856				2,856	
	P H D				1	1			52	52				3,759	3,759	
Total		1			1	2	104		52	156	2,856			3,759	6,615	
Hockley	Slaughter	247	1		1	249	15,881		32	15,913	1,233,972	55		5,053	1,239,080	
	Smyer	2				2	279			279	11,920				11,920	
	Yellowhouse	1				1	74			74	4,673				4,673	
Total		250	1		1	252	16,234		32	16,266	1,250,565	55		5,053	1,255,673	810,869
Howard	Howard-Glasscock	15	2		2	19	381		22	403	31,823	899		2,786	35,508	
	Iatan East Howard	19			5	24	1,639		470	2,109	52,840			12,406	65,246	
	Iatan North	8			1	9	561		83	644	23,048			3,027	26,075	
	Moore	10			1	11	896		140	1,036	32,458			3,280	35,738	
	Morita	3				3	336			336	10,011				10,011	
	Snyder	1				1	135			135	3,066				3,066	
	Vincent	1	1			2	279			279	4,310	309			4,619	
Total		57	3		9	69	4,227		715	4,942	157,556	1,208		21,499	180,263	54,913
Irion	Irion Total	1			1	2	78		47	125		1,456		1,491	2,947	
Lubbock	Total															9,852
Mitchell	Iatan East Howard	10				10	570			570	28,408				28,408	
	Iatan North	1				1	68			68	2,860				2,860	
	Westbrook	52			1	53	4,993		71	5,064	161,890			2,944	164,834	
Total		63			1	64	5,631		71	5,702	193,158			2,944	196,102	41,293

TABLE 7.—(*Continued*)

County	Field	Number of Oil Wells	Number Oil Wells Drilled Deeper	Number Gas Wells	Number Dry and Abandoned	Total	Estimated Completion Days: Oil	Estimated Completion Days: Gas	Estimated Completion Days: Dry	Estimated Completion Days: Total	Total Footage Drilled: Oil	Total Footage Drilled: Oil Wells Drilled Deeper	Total Footage Drilled: Gas	Total Footage Drilled: Dry	Total Footage Drilled: 1944 Total	Total Footage Drilled: 1943 Total
Pecos	Abell	2	1		1	4	254		41	295	11,734	420		1,617	13,771	
	Abell Permian	1				1	72			72	2,312				2,312	
	Apco 1600	6	1		2	9	338		129	467	9,988	15		3,374	13,377	
	Apco Warner	5	1	1	2	9	533	84	150	767	23,675	85	4,673	10,142	38,575	
	Chancellor				2	2			494	494				10,935	10,935	
	Fort Stockton	3				3	227			227	10,907				10,907	
	Heiner				1	1			152	152				6,100	6,100	
	Lehn	5			1	6	660		48	708	7,927			1,694	9,621	
	MacDer			1		1		106		106			5,238		5,238	
	McCandless				2	2			212	212				8,621	8,621	
	Pecos Valley HG	2				2	401			401	3,440				3,440	
	Taylor Link	4	1		2	7	311		136	447	6,130	32		3,770	9,932	
	Toborg	2	1		2	5	48		40	88	785	100		900	1,785	
	Walker	3	2			5	238			238	5,882	62			5,944	
	Wentz				2	2			117	117				7,594	7,594	
	White and Baker	5		2	2	9	195	199	165	559	8,676		3,698	4,240	16,614	
	Yates	12			4	16	913		310	1,223	21,707			7,883	29,590	
Total		50	7	4	23	84	4,190	389	1,994	6,573	113,163	714	13,609	66,870	194,356	247,516
Reagan	Barnhart	12				12	1,284			1,284	110,368				110,368	
	Big Lake				2	2			374	374				17,122	17,122	
	Grayson	1			1	2	95		42	137	3,080			4,530	7,610	
Total		13			3	16	1,379		416	1,795	113,448			21,652	135,100	151,432
Scurry	Sharon Ridge Total	6				6	660			660	15,572				15,572	23,284
Schleicher	Page Total				1	1			290	290				5,757	5,757	
Terry	Slaughter Total	7			1	8	418		38	456	35,453			4,560	40,013	20,170
Tom Green	Funk Total	13			1	14	1,341		40	1,381	14,737			1,090	15,827	1,175
Upton	Crane Cowden		1			1						158			158	
	Crossett	2				2	303			303	10,885				10,885	
	McCamey	3	25		3	31	106		133	239	8,087	1,019		7,964	17,070	
	McElroy	6	1			7	279			279	18,036	51			18,087	
Total		11	27		3	41	688		133	821	37,008	1,228		7,964	46,200	20,928
Ward	Estes	5	9			14	281			281	13,062	2,196			15,258	
	Monahans	3				3	1,227			1,227	31,324				31,324	
	North Ward	37			1	38	1,181		57	1,238	105,706			3,150	108,856	
	Payton	1				1	186			186	2,303				2,303	
	Pecos Valley HG				1	1			364	364				4,362	4,362	
	Shipley	1	1		2	4	127		245	372	2,485	76		5,033	7,594	
	South Ward	1	7			8	106			106	2,400	678			3,078	
Total		48	17		4	69	3,108		666	3,774	157,280	2,950		12,545	172,775	63,309

TABLE 7.—(*Continued*)

County	Field	Number of Oil Wells	Number Oil Wells Drilled Deeper	Number Gas Wells	Number Dry and Abandoned	Total	Estimated Completion Days: Oil	Estimated Completion Days: Gas	Estimated Completion Days: Dry	Estimated Completion Days: Total	Total Footage Drilled: Oil	Total Footage Drilled: Oil Wells Drilled Deeper	Total Footage Drilled: Gas	Total Footage Drilled: Dry	Total Footage Drilled: 1944 Total	Total Footage Drilled: 1943 Total
Winkler	Eaves	11			1	12	579		46	625	34,807			3,636	38,443	
	Emperor	6				6	206			206	17,282				17,282	
	Emperor Deep	2				2	95			95	6,263				6,263	
	Halley	13				13	503			503	38,772				38,772	
	Halley Extension	3				3	228			228	9,580				9,580	
	Hendrick			1		1		99		99			2,916		2,916	
	Kermit Ellenburger				1	1			343	343				10,896	10,896	
	Keystone	3	4	1		8	230	26		256	10,302	5,609	2,770		18,681	
	Keystone Colby Sand	20		1		21	1,471	61		1,532	67,116		3,112		70,228	
	Keystone Ellenburger	12				12	2,765			2,765	118,668				118,668	
	Keystone Holt	1	4			5	107			107	4,790	4,993			9,783	
	Leck	2			1	3	208		86	294	6,271			3,228	9,499	
	North Monahans	2			1	3	313		159	472	12,686			6,399	19,085	
	North Ward	10				10	492			492	29,073				29,073	
	Weiner	16			2	18	875		275	1,150	50,302			6,351	56,653	
	Wheeler Ellenburger	7				7	1,668			1,668	74,945				74,945	
Total		108	8	3	6	125	9,740	186	909	10,835	480,857	10,602	8,798	30,510	530,767	137,094
Yoakum	Ownby	15			1	16	1,004		81	1,085	79,916			5,367	85,283	
	Waples Platter	9			1	10	811		245	1,056	47,676			5,300	52,976	
	Wasson	45	2		2	49	3,070		620	3,690	233,591	140		10,445	244,176	
	West				1	1			49	49				2,195	2,195	
Total		69	2		5	76	4,885		995	5,880	361,183	140		23,307	384,630	35,281
Total Field Wells		1,325	76	10	102	1,513	104,367	846	9,979	115,026	6,166,038	17,674	28,403	377,869	6,589,984	3,595,915
Total Wildcat Wells		36		6	167	209	5,610	790	19,289	25,689	185,381		29,960	844,598	1,059,939	515,404
Total Drilled Wells		1,361	76	16	269	1,722	109,977	1,636	29,268	140,715	6,351,419	17,674	58,363	1,222,467	7,649,923	4,147,319

TABLE 8.—*New Discoveries during 1944 in West Texas*

	County	Field	Discovery Well	Total Depth, Ft.	Plugback Depth, Ft.	Producing Horizon	Gravity	Top of Pay, Ft.	Gas-Oil Ratio
			NEW OIL FIELDS						
1	Andrews......	Stano-Midland Farms	Stanolind Oil & Gas Co. No. 1-F Midland Farms	4,942	4,880	Grayburg-Permian	31.6	4,820	160
2	Crane.........	Crossett	Texas Co. No. 1-A C. W. Hobbs	6,021	5,440	Lower Devonian	45.0	5,300	1,900
3	Ector.........	TXL	Shell & Cities Service Oil Co. No. 1 T.X.L.	10,181	8,050	Lower-Devonian	41.0	7,886	873
4	Gaines.......	Doss	Humble Oil & Ref. Co. No. 1 Humble Fee et al.	9,049	7,080	Clear Fork Permian	33.6	7,030	517
5	Garza........	PHD	Honolulu & Devonian Oil Co. No. 1 D. R. Payton	3,768	3,565	San Andres-Permian	38.1	3,544	360
6	Hockley......	Yellowhouse	Stanolind Oil & Gas Co. No. 1 Tom Cobb	4,685	4,663	San Andres-Permian	27.0	4,596	(Pump)
7	Pecos........	Fort Stockton	Humble Oil & Ref. Co. No. 1 O. W. Williams	3,604	2,892	Yates-Permian	35.7	2,840	1,650
8	Pecos........	Debs	Burke Royalty Co. No. 1 Iowa Realty Trust	1,477	1,356	Seven Rivers-Permian		1,300	800
9	Ward........	Lion	Lion Oil & Ref. Co. 1-B University	4,994		Delaware-Permian	35	4,979	825
10	Winkler......	North Monahans	Stanolind Oil & Gas Co. No. 1 Sealy Smith Foundation	6,305	6,248	Clear Fork-Permian	37	6,005	2,998
			EXTENSIONS TO OLD OIL FIELDS						
11	Andrews......	North Cowden	Phillips Petr. Co. et al. 1-H Tex. Univ.	4,717		Grayburg-Permian	30.8	4,625	(Pump)
12	Andrews......	Means	Signal Oil & Gas Co. No. 1 M. M. Fisher	4,628	4,606	San Andres-Permian	28.5	4,596	(Pump)
13	Andrews......	Means	Sun Oil Co. No. 1 F. E. Gardner	4,562		San Andres-Permian	31.5	4,430	486
14	Andrews......	Clabberhill	Texas Company No. 1-L Univ.	5,520	5,330	San Andres-Permian	33.0	5,310	595
15	Andrews......	Deep Rock	Texas Company No. 1 A. W. Patillo	4,414		San Andres-Permian	33.0	4,280	483
16	Andrews......	Deep Rock	Texas Company No. 1 E. B. Jones et al.	6,242	4,490	San Andres-Permian	33.2	4,370	407
17	Cochran......	Slaughter	E. Constantine, Jr. No. 1 G. W. Moore	4,952	4,911	San Andres-Permian	31.0	4,862	130
18	Cochran......	Slaughter	Helmerich & Payne, Inc. No. 1 D. S. Wright	4,925		San Andres-Permian	31.4	4,905	small
19	Cochran......	Slaughter	Falcon Oil Co. No. 1 C. S. Dean	5,035		San Andres-Permian	29.1	4,925	(Pump)
20	Cochran......	Slaughter	San Andres Prod. Co. No. 1 M. N. Clauser	4,875		San Andres-Permian	30.0	4,860	600
21	Crane........	Barnsley (Sand Hills Tubb)	J. I. Moore No. 1 T. C. Barnsley Est.	4,651		Clear Fork-Permian	34.5	4,500	(Pump)
22	Crane........	Sand Hills Tubb	Schermerhorn Oil Corp. No. 1 M. B. McKnight	4,757		Clear Fork-Permian	35.7	4,490	1,210
23	Crockett.....	Shannon	Standard Oil Co. of Ohio No. 1 Shannon Est.	2,215		San Andres-Permian		2,190	(Pump)
24	Ector........	Foster	M. B. K. Drilling Co. E-1 J. M. Gist	4,450	4,444	Grayburg-Permian	34.8	4,410	179
25	Howard......	Morita	J. B. Hawley Jr. No. 1 J. W. Cook	3,516	3,290	Grayburg-Permian?	25.4	3,193	(Pump)
26	Howard......	Iatan East Howard	L. C. Harrison No. 1 D. H. Snyder	3,051		San Angelo-Permian	28.0	2,800	(Pump)
27	Pecos........	Yates	James T. Brewer No. 1 F. A. Perry	1,920		San Andres-Permian	32.0	1,875	450
28	Reagan.......	Grayson	Superior Oil Co. of Calif. & Wiggins & Hyde No. 1-A Univ.	3,175		Grayburg-Permian	32.2	3,152	(Pump)
29	Winkler......	North Monahans	Texas Co. No. 1 Geo. D. Hogg	6,287	6,140	Clear Fork-Permian	36.0	6,100	1,259
30	Winkler......	Kermit Ellenburger	Magnolia Petr. Co. No. 21 Ellen-State-Walton	10,680		Ellenburger Ordovician	46.6	10,635	5,488
31	Yoakum......	Wasson	Woodley Petr. Co. No. 1 Mattie E. Farmer	5,340	5,315	San Andres-Permian	28.0	5,239	(Pump)

TABLE 8.—(*Continued*)

	County	Field	Discovery Well	Total Depth, Ft.	Plugback Depth, Ft.	Producing Horizon	Gravity	Top of Pay, Ft.	Gas-Oil Ratio
			NEW HORIZONS IN OLD OIL FIELDS						
32	Andrews......	Fullerton 3100 ft.	Magnolia Petr. Co. 3-11 B. B. Ralph	3,150		Yates-Permian	?	3,050	Pump 27.6 BOPD
33	Andrews......	Fullerton 8500 ft.	Mid-Continent Petr. Corp. 1-7 Univ.	8,955		Upper Devonian	40.0	8,460	342
34	Crane........	Northeast Sand Hills Ordovician	Gulf Oil Corp. 43-E W. N. Waddell	5,881	5,851	Ellenburger Ordovician	35.6	5,799	440
35	Crockett.....	Todd Ellenburger	Amerada Petr. Corp. A-5 Todd Est.	6,285	(5,950)[a]	Ellenburger Ordovician	41.3	6,130	708
36	Howard.......	Vincent 5500 ft.	W. S. Guthrie & Cosden Petr. Corp. No. 2, Pauline Allen	6,172	5,500	Wolfcamp Permian	33.6	5,450	500
			NEW GAS FIELDS						
37	Crockett.....	Clara Couch	E. J. McCurdy No. 1 W. L. Hobbs	1,526		Seven Rivers Permian		1,501	
38	Gaines.......	Homann	Honolulu Oil Corp. No. 1 E. B. Homann	5,457	3,513	Yates Permian		3,475	
39	Pecos........	MacDer	Standard Oil Co. of Texas No. 1-4 Mac Der	5,313	4,730	Wolfcamp Permian		4,706	
			EXTENSIONS TO OLD GAS FIELDS						
40	Andrews......	Shafter Lake	Cities Service Oil Co. 1-L University	6,942	3,720	Yates Permian		2,966	
41	Pecos........	MacDer	Standard Oil Co. of Texas 1-5 MacDer	5,020	4,580	Wolfcamp Permian		?	
42	Schleicher....	Page	Globe Oil & Ref. Co. No. 1 T. R. Henderson	5,702		Strawn Pennsylvanian		5,455	

[a] Todd deep field completion.

TABLE 9.—*Distribution of Wildcat Development*, 1944, *West Texas*

County	Number of Wells				Estimated Completion Days				Total Footage Drilled				
	Oil	Gas	Dry	Total	Oil	Gas	Dry	Total	Oil	Gas	Dry	Total 1944	Total 1943
Andrews	9	1	9	19	1,199	156	1,852	3,207	47,130	6,942	79,688	133,760	74,874
Borden			1	1			31	31			3,346	3,346	4,518
Brewster[a]			2	2			344	344			2,819	2,819	
Cochran	4		3	7	499		195	694	19,787		15,278	35,065	15,408
Coke			1	1			284	284			1,938	1,938	1,851
Crane	4		5	9	620		536	1,156	21,310		28,566	49,876	16,583
Crockett	2	1	10	13	332	57	1,101	1,490	8,500	1,526	33,325	43,351	25,219
Crosby													3,515
Culberson			4	4			881	881			15,736	15,736	
Dawson			6	6			654	654			39,078	39,078	5,512
Dickens			3	3			220	220			14,750	14,750	
Ector	2		2	4	314		319	633	14,631		10,829	25,460	9,631
Gaines	1	1	13	15	245	210	1,478	1,933	9,049	5,457	81,298	95,804	43,205
Garza	1		2	3	105		90	195	3,768		6,615	10,383	3,924
Glasscock			3	3			284	284			13,408	13,408	
Hockley	1		3	4	115		194	309	4,685		18,205	22,890	30,525
Howard	3		8	11	591		559	1,150	12,739		30,401	43,140	7,038
Hudspeth			2	2			336	336			1,425	1,425	
Irion			2	2			425	425			17,858	17,858	2,527
Loving			4	4			436	436			16,840	16,840	
Lubbock			2	2			98	98			11,619	11,619	11,242
Lynn			5	5			526	526			34,026	34,026	
Martin			3	3			119	119			15,196	15,196	12,738
Midland			3	3			108	108			15,810	15,810	
Mitchell			5	5			1,042	1,042			32,220	32,220	7,118
Pecos	3	2	29	34	513	187	3,143	3,843	7,001	10,333	117,624	134,958	99,562
Reagan	1		5	6	174		568	742	3,175		24,918	28,093	9,995
Reeves			5	5			823	823			21,093	21,093	5,008
Runnels													4,735
Schleicher		1	1	2		180	97	277		5,702	6,065	11,767	7,021
Scurry													16,349
Sterling													32,779
Sutton													8,197
Terrell			1	1			193	193			2,367	2,367	
Terry			3	3			194	194			16,525	16,525	5,553
Tom Green			3	3			156	156			8,074	8,074	6,384
Upton			3	3			212	212			12,008	12,008	6,207
Ward	1		4	4	125		619	744	4,994		20,265	25,259	8,130
Winkler	3		2	2	679		459	1,138	23,272		18,805	42,077	30,775
Yoakum	1		10	10	99		713	812	5,340		56,580	61,920	35,281
Total	36	6	167	204	5,610	790	19,289	25,689	185,381	29,960	844,598	1,059,939	551,404

[a] One temporarily abandoned well deepened.

TABLE 10.—*Capacities of Main Pipe Lines*

Company	Lines	Capacities, Bbl.	
		Jan. 1, 1944	Dec. 31, 1944
Atlantic	10″	42,000	42,000
Gulf	10″	70,000	85,000
Humble	Two 8″	50,000	50,000
	12″	66,000	66,000
Magnolia	8″	29,000	21,000[a]
	12″		58,000
Shell	10″	46,000	46,000
	10″	37,000	37,000
Stanolind	16″		65,000
Texas New Mexico	12″	66,000	66,000[b]
Totals		406,000	536,000
Atlantic	Loading rack	45,000	45,000

[a] Magnolia plans to increase its 12-in. line to 65,000 bbl. capacity.

[b] Texas New Mexico line now being increased by 5000 barrels.

TABLE 11.—*Subsidy for Stripper Fields*

20¢ Field	25¢ Field	35¢ Field
Clara Couch	Crockett	Crane Cowden
Emperor Deep	Deep Rock	Hurdle
Goldsmith North	Dobbs	Kermit
Halley	Fromme	Lehn
Sand Hills West	Moore	Live Oak
Scarborough	Payton	Masterson
Shearer	Sharon Ridge	Netterville
Simpson	Snyder	Pecos Valley Low Gravity
Westbrook	Toborg	Pecos Valley High Gravity
		South Ward
		Webb Ray
		West Andrews
Effective December 1, 1944		
	Sharon Ridge 2440′	Sharon Ridge 1700′
Effective January 1, 1945		
		Pruitt

TABLE 12.—*Field Price Increases, West Texas*

Date	Company	Field	Price—2¢ Increase for Each Degree of Gravity Increase above Minimum Shown
Aug. 1944	Magnolia	Kermit Ellenburger	Below 25—93¢, 40 and above—$1.25
		Keystone Ellenburger	Below 25—93¢, 40 and above—$1.25
Aug. 1944	Gulf	Keystone Ellenburger	Below 25—93¢, 40 and above—$1.25
Aug. 1944	Magnolia	Fullerton	Below 25—93¢, 40 and above—$1.25
		Union	Below 25—93¢, 40 and above—$1.25
Nov. 1944	Humble	Barnhart	Below 25—93¢, 40 and above—$1.25
Mar. 1945	Gulf	Sand Hills Ellenburger West	40 and above—$1.25
Jan. 1945	Shell[a]	Monahans North	40 and above—$1.25
		Wheeler Ellenburger	40 and above—$1.25
		T. X. L.	40 and above—$1.25

[a] Shell has applied for price increase, which has not been posted.

Knight" pay, which resulted in the division of the Sand Hills Permian field into the Sand Hills McKnight and Sand Hills Tubb fields.

It is conservatively estimated that new discoveries and extensions to known fields have increased known oil reserves to more than compensate for the 159,000,000 bbl. of oil produced.

Leasing

Leasing activity continued heavy and general throughout the area with rising prices. At two competitive University Land sales, the University received $6,852,900 for leases on 64,265 acres. An estimated 7,500,000 acres are under lease in West Texas. Customary lease rental amounts to $0.50 per acre per year.

Acknowledgment

The author acknowledges the cooperative assistance of several individuals in the collection of data and preparation of this summary of operations. Because of lack of personnel, many valuable field data are not currently being obtained. The gas-production data are both meager and subject to inaccuracies.

Oil and Gas Development in West Virginia during 1944

By David B. Reger,* Member A.I.M.E.

Widespread wildcatting for new supplies of natural gas and the beginning of importation from the southwest characterized the petroleum industry of West Virginia during 1944. Within the state, drilling for oil did not increase but more gas wells were completed than in any previous year since 1937. Out of 40 wildcats drilled there were 25 gas discoveries and 15 dry holes. No commercial oil was found in the 40 wells.

Table 1.—*Production Statistics, West Virginia*

Period	Oil			Gas		
	Number of Wells	Bbl. Produced	Average Oil per Well Daily, Bbl.	Number of Wells	Millions Cu. Ft. Produced	Average Gas per Well per Day, Cu. Ft.
To end of 1944		427,756,000			7,551,838	
During 1943	17,051	3,349,000[a]	0.54	14,309	223,787[a]	43,848
During 1944	16,622	3,069,000[b]	0.50	14,720	200,000[c]	37,225

[a] U. S. Bureau of Mines, final figures.
[b] *Oil Weekly*, estimate.
[c] Author's estimate.

The proved limits of several oil pools were slightly extended by marginal drilling, resulting in 1300 acres of new oil territory, although no distinctly new pools were found. At least four new gas pools were assuredly discovered and various successful wildcats indicate future pools or wide extensions. The new proved gas territory, in definite new pools and definite extensions, is about 34,000 acres. A considerable net decline of proved oil has occurred and probably a slight decline of proved gas reserves.

The account of operations, as gathered from trade journals and other reporting services, shows that 918 new wells were drilled, resulting in 71 oil wells with 613 bbl. of daily new production; 577 gas wells with 305,372,000 cu. ft. of daily open flow, and 142 dry holes. Also, 107 old wells were drilled to deeper sands, with 22 bbl. and 12,327,000 cu. ft. of added production. On the new wells the oil average was 8.6 bbl. per well per day, and the gas average was 529,241 cu. ft. per well per day. On new wells the ratio of dry holes to completions was 15.47 per cent. On deeper drilling the ratio of failures was 19.63 per cent.

Production of oil for the year was estimated by the *Oil Weekly* as 3,069,000 bbl., as compared with 3,349,000 bbl. in 1943.

Production of natural gas for the year is estimated by the author as 200,000,000,000 cu. ft., as compared with the U. S. Bureau of Mines final figures of 223,789,000,000 cu. ft.† in 1943.

Manuscript received at the office of the Institute March 23, 1945.

* Consulting Geologist, Morgantown, West Virginia.

† The Public Service Commission of West Virginia reports (by letter) 248,151,649,000 cu. ft. Its estimate of 1944 production is the same as that of the author.

TABLE 2.—*New Pools and Extensions*

Pool (Oil or Gas), County and Producing Sand	Period	Wells, Initial Production and Proved Territory							Wells Drilling, End of 1944
		Oil		Gas					
		No. Wells	Avg. Bbl. per Well per Day	No. Wells	Avg. Mcf. per Well per Day	Avg. R.P., Lbs.	Dry Holes	Proved Acres	
Overfield (gas) Barbour—Ril., Ben.[a]	Before 1944	0		24	544		2	4,400	
	During 1944	0		8	378	1,410	0	100	
	Total	0		32	502		2	4,500	6
Anthony Fork (oil) Braxton—Salt	Before 1944	8	12	1			5	400	
	During 1944	1	40	0			1	100	
	Total	0	19	1			6	500	0
Sycamore (oil) Calhoun—B. I.	Before 1944	54	15.3	7	241	350	2	1,700	
	During 1944	5	8.8	2	200		0	300	
	Total	59	14.4	9	229	350	2	2,000	6
Morocco (gas) Clay—B.Lm., B. I.	Before 1944	0		11	1,285		2	1,000	
	During 1944	0		1	158	480	0	100	
	Total	0		12	1,144		2	1,100	3
Reed Fork (oil) Clay—B. I.	Before 1944	96?	?	?			?	1,300	
	During 1944	6	4.7	0			0	0	
	Total	102?	?	?			?	1,300	1
Villa Nova (gas) Braxton and Clay—Salt, Blue M., B. Lm., B. I.	Before 1944	2	50	104	1,077	477	40	19,000	
	During 1944	0		29	414	389	3	2,000	
	Total	2	50	133	919	455	43	21,000	7
Wade Fork (gas) Clay—Salt, Knr., B. I.	Before 1944	2	6	15	1,396	450	5	3,500	
	During 1944	0		1	696	186	1	0	
	Total	2	6	16	1,346	426	6	3,500	1
Charleston gas field (excluding Higginbotham Run oil pool and Rocky Fork gas pool). Jackson, Kanawha and Putnam—Oriskany	Before 1944	1	150	915	5,449	1,437?	76	140,000	
	During 1944	0	0	18	2,006	1,439	7	0	
	Total	1	150	933	5,335	1,437?	83	140,000	12
Leroy (oil) Jackson—Be.	Before 1944	6	27.8	1	246		2	600	
	During 1944	1	15	0			0	0	
	Total	7	26.1	1	246		2	600	4
Crown Hill (gas) Kanawha—B. Lm., Sq., Weir, Be.	Before 1944	0		13	873	385	1	1,000	
	During 1944	0		13	440	335	0	1,500	
	Total	0		26	592	375	1	2,500	7
Eightmile Fork (gas) Kanawha—Sq., Be.	Before 1944	0		7	172	473	0	300	
	During 1944	0		4	179		1	300	
	Total	0		11	175	473	1	600	0
Fry (gas, new) Kanawha—Salt, B. I.	Before 1944	0		0			0	0	
	During 1944	0		7	660	705	1	600	
	Total	0		7	660	705	1	600	2
Rocky Fork (gas) Kanawha and Putnam—B. Lm.	Before 1944	0		14	4,229	578	2	1,400	
	During 1944	0		10	565	461	5	600	
	Total	0		24	2,702	539	7	2,000	1
Witchers Creek (gas) Kanawha—B. I., Weir	Before 1944	0		4	370	?	0	400	
	During 1944	0		5	161	?	0	600	
	Total	0		9	221	?	0	1,000	2
Bradyville (gas) Lincoln—B. Lm., B. I., Be., B. Sh.	Before 1944	0		12	691	421	0	700	
	During 1944	0		24	247	358	0	4,200	
	Total	0		36	395	397	0	4,900	4
Griffithsville (oil) Lincoln—Be.	Before 1944	410?	?	?	?	?	?	15,700	
	During 1944	3	4.3	0			1	0	
	Total	413?	?	?	?	?	?	15,700	1
Spurlockville (gas) Lincoln—Be., B. Sh.	Before 1944	0		79+	385	400	6	22,000	
	During 1944	1	10	29	259	292	1	1,400	
	Total	1	10	108+	345	388	7	23,400	15
Holden (gas, new) Logan—B. Lm.	Before 1944	0		0			0	0	
	During 1944	0		3	2,605	550	0	300	
	Total	0		3	2,605	550	0	300	0
Swiss (gas, new) Nicholas—B. Lm., B. I.	Before 1944	0		1	750		0	0	
	During 1944	0		7	2,248	526	0	1,500	
	Total	0		8	2,061	526	0	1,500	14
Heizer (gas) Putnam—B. Lm.	Before 1944	0		6	1,906	685	7	1,200	
	During 1944	0		2	5,574	375	4	200	
	Total	0		8	2,823	596	11	1,400	1

[a] Abbreviations as follows: Ball., Balltown; Ben., Benson; Be., Berea; B.I., Big Injun; B.Lm., Big Lime; Blue M., Blue Monday; B.Sh., Brown Shale; 5th, Fifth; 50-ft., Fifty-foot; 4th, Fourth; Gord., Gordon; G.Stray, Gordon Stray; Knr., Keener; Max., Maxton; Pr., Princeton; Ril., Riley; Sec.C.R., Second Cow Run; Sq., Squaw; S.G., Stony Gap.

TABLE 2.—(*Continued*)

Pool (Oil or Gas), County and Producing Sand	Period	Wells, Initial Production and Proved Territory: Oil: No. Wells	Oil: Avg. Bbl. per Well per Day	Gas: No. Wells	Gas: Avg. Mcf. per Well per Day	Gas: Avg. R.P., Lbs.	Dry Holes	Proved Acres	Wells Drilling, End of 1944
Trace Fork (gas) Putnam—Salt, B. Lm., Be., B. Sh.	Before 1944	1	45	133	548	484	5	23,000	
	During 1944	0		17	144	473	0	1,000	
	Total	1	45	150	501	482	5	24,000	9
Rock Creek (gas, new) Raleigh—Max.	Before 1944	0		0			0	0	
	During 1944	0		2	2,015	573	0	200	
	Total	0		2	2,015	573	0	200	3
Slab Fork (gas) Raleigh—S. G., Max., B. Lm.	Before 1944	0		15	888	527	5	2,900	
	During 1944	0		4	341	527	5	1,100	
	Total	0		19	773	527	10	4,000	1
Lost Run (gas), Taylor—B. I.	Before 1944	1	10	11	253	237	5	800	
	During 1944	0		1	26	195	1	100	
	Total	1	10	12	220	231	6	900	1
Evergreen (gas) Upshur—Weir, Gord., 4th, 5th, Ball., Ril., Ben.	Before 1944	0		45	493	530	14	5,000	
	During 1944	0		17	282	471	8	6,000	
	Total	0		62	430	515	22	11,000	7
Lorentz (gas), Upshur—50 ft., Gord., 5th., Ben.	Before 1944	0		34	394	1,192	4	4,000	
	During 1944	0		13	288	1,267	6	2,000	
	Total	0		47	365	1,214	10	6,000	6
Rock Cave (gas), Upshur—B. I., Sq., G. Stray, Gord., 5th, Ril., Ben.	Before 1944	0		27	445	583	4	4,200	
	During 1944	0		7	122	680	2	600	
	Total	0		34	388	596	6	4,800	2
Crum (gas), Wayne—Salt, B. Lm., B. I., B. Sh.	Before 1944	1	2	13	1,549	436	4	4,000	
	During 1944	0		24	319	425	0	2,500	
	Total	1	2	37	626	433	4	6,500	4
Ogdin (oil) Wood—Sec. C. R., Be.	Before 1944	35?	23.4?	1?	134?	280?	3?	1,600	
	During 1944	2	17.5	3	1,317	800	4	300	
	Total	37?	23.0?	4?	1,021?	540?	7?	1,900	8
Glen Morrison (gas) Wyoming—Pr., B. Lm.	Before 1944	0		8	321	441	1	3,000	
	During 1944	0		1	158		0	0	
	Total	0		9	301	441	1	3,000	0
Pineville (gas), Wyoming—Pr., Max., B. Lm., Be.	Before 1944	0		12	1,007	643	1	4,500	
	During 1944	0		17	591	617	0	7,200	
	Total	0		29	764	628	1	10,700	12

GENERAL STATE OF INDUSTRY

Leasing of wildcat acreage was extremely active. The total land of all classes under lease may approximate 6,000,000 acres. Taking into consideration completions, abandonments and corrected figures or estimates, Table 1 shows cumulative and late annual statistics.

NEW POOLS AND EXTENSIONS

Table 2 shows the principal areas of drilling activity during 1944. In addition to these new or active areas considerable routine drilling was done in numerous other pools, and in areas where pool boundaries can hardly be defined.

SUMMARY OF EXPLORATIONS

Table 3 gives a summary of important wildcat or exploratory wells drilled during 1944, together with some others that have gone to unusual depths in old fields.

DEVELOPMENT IN ORISKANY AND OTHER DEEP SANDS

Drilling to the deep Oriskany sand (L. Dev.) continued to decline in 1944, the total count showing 40 tests, of which 20 had commercial gas and one a small amount of oil. Of the productive wells 19 were in the Charleston gas field, including a large-volume outpost in Elk District, Kanawha County, that may represent a distinctly new pool unless the intervening 5-mile gap should prove productive. Outside of the Charleston field, two dry tests were made in Boone and two in Hancock. One small gas well was completed in Lewis. Preston, Putnam and

TABLE 3.—*Important Wildcats Drilled in West Virginia during 1944*

Line No.	County	Magisterial District	Location: Lat.	Location: Long.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Property and Well No.	Initial Production per Day: Oil, Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Tubing or Casing Pressure, Lb. per Sq. In.	Remarks
1	Boone.......	Peytona	1.50 mi. S. of 38°10′	4.14 mi. W. of 81°40′	5,600	Pen-Kanawha	Sil-W. Medina	Owens-Libbey-Owens	Coal River Mining Co., "A" 37-656	0	0	0	Dry through "Clinton"
2	Boone.......	Sherman	1.78 mi. S. of 38°05′	1.76 mi. W. of 81°40′	4,818	Pen-Kanawha	M. Dev-Marcellus	United Carbon Co.	Southern Land Co., 1-1131	0	0.103		Brown Shale gas well
3	Boone.......	Crook	1.50 mi. S. of 37°50′	3.26 mi. W. of 81°30′	2,221	Pen-Kanawha	U. Mis-Bluefield	Hope N. G. Co.	Loup Creek Colliery Co., 1-8867	0	0.852	300 (1 hr.)	Maxton gas well
4	Boone.......	Crook	0.40 mi. S. of 37°55′	0.67 mi. W. of 81°40′	2,880	Pen-Kanawha	L. Mis-Pocono	United Producing Co.	Donald D. Shepard, 1-1168	0	0.219	600 (24 hr.)	Big Injun and Weir gas well
5	Braxton.....	Otter	0.42 mi. S. of 38°40′	0.90 mi. W. of 80°45′	2,294	Pen-Conemaugh	L. Mis-Pocono	Rexroad & Robinson	Ada B. Nuzum, 1	0	0	0	Dry through Big Injun
6	Clay........	Henry	4.13 mi. S. of 38°30′	2.85 mi. W. of 80°55′	2,336	Pen-Allegheny	L. Mis-Greenbrier	Thompson Gas Co.	Geo. Salisbury, T70	0	0.103	386 (48 hr.)	Big Lime gas well
7	Fayette.....	Falls	3.25 mi. S. of 38°15′	1.29 mi. W. of 81°05′	2,252	Pen-New River	L. Mis-Pocono	Columbian Carbon	Gauley Mountain Coal Co., 1-GW	0	0	0	Dry through Berea
8	Hancock....	Grant	1.64 mi. S. of 40°35′	2.06 mi. W. of 80°30′	4,995	Pen-Conemaugh	L. Dev-Oriskany	Smith Petroleum Co.	C. A. Smith, 1	0	0	0	Dry through Oriskany (salt water)
9	Jackson.....	Ripley	1.38 mi. S. of 38°50′	2.03 mi. W. of 81°45′	4,594	Perm-Dunkard	L. Dev-Oriskany	Harlan Staats	W. M. King, 1	0	0.010	0	Oriskany gas show; abandoned
10	Jackson.....	Ripley	5.05 mi. S. of 38°50′	3.25 mi. W. of 81°40′	5,005	Perm-Dunkard	L. Dev-Oriskany	United Carbon Co.	Russell D. Hutchinson, 1-1194	0	2.113	1680 (48 hr.)	Oriskany gas well
11	Jackson.....	Ravenswood	1.93 mi. S. of 38°55′	1.48 mi. W. of 81°40′		Perm-Dunkard	Pen-New River	United Carbon Co.	J. C. Fisher, 1-1199	0	0.933	460 (40 min.)	Salt Sand gas well
12	Kanawha....	Union	4.37 mi. S. of 38°30′	1.22 mi. W. of 81°45′	1,687	Pen-Conemaugh	L. Mis-Pocono	Columbian Carbon	Lucy P. Dickerson, 1-GW 738	0	0.622	720 (72 hr.)	Salt and Big Injun gas well
13	Kanawha....	Cabin Creek	0.70 mi. S. of 38°15′	1.30 mi. W. of 81°25′	5,312	Pen-Kanawha	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	Wm. Bowers Est., 4-625	0	0	0	Dry through Oriskany (salt water)
14	Kanawha....	Elk	0.67 mi. S. of 38°25′	1.02 mi. W. of 81°25′	5,405	Pen-Conemaugh	L. Dev-Oriskany	United Fuel Gas Co.	Edward Gebhart, 2-5504	0	10.000		Oriskany gas well
15	Lewis.......	Collins Settlement	2.50 mi. S. of 38°55′	3.22 mi. W. of 80°20′	4,210	Pen-Conemaugh	U. Dev-Chemung	Hanley & Bird	John S. Rexroad, 1-16	0	0	0	Dry through Benson
16	Lincoln......	Harts Creek	2.38 mi. S. of 38°05′	2.27 mi. W. of 82°00′	4,022	Pen-Kanawha	L. Dev-Helderberg?	Owens-Libbey-Owens	Koontz Realty Co., 1-692	0	0.172	477 (34 hr.)	Helderberg Lime? gas well
17	Logan.......	Triadelphia	5.15 mi. S. of 37°50′	2.35 mi. W. of 81°45′	3,369	Pen-Kanawha	L. Mis-Pocono	South Penn Natural Gas	Buffalo Creek Coal & Coke Co., 1	0	0.565		Big Lime, Big Injun and Shells gas well
18	Logan.......	Logan	0.26 mi. S. of 37°50′	2.60 mi. W. of 82°05′	2,037	Pen-Kanawha	L. Mis-Greenbrier	Columbian Carbon	Island Creek Coal Co., 1-GW 746	0	5.439	545 (82 hr.)	Big Lime gas well
19	Logan.......	Logan	3.68 mi. S. of 37°55′	1.19 mi. W. of 82°05′	4,022	Pen-Kanawha	M. Dev-Marcellus	Columbian Carbon	Island Creek Coal Co., 2-GW 747	0	0.158	365 (40 hr.)	Brown Shale gas well
20	Logan.......	Logan	4.65 mi. S. of 37°55′	3.25 mi. W. of 82°00′	4,342	Pen-Kanawha	M. Dev-Marcellus	Columbian Carbon	Island Creek Coal Co., 3-GW 748	0	0.198	50 (30 min.)	Berea and Brown Shale gas well

TABLE 3.—(*Continued*)

Line No.	County	Magisterial District	Location: Lat.	Location: Long.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Property and Well No.	Initial Production per Day: Oil, Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Tubing or Casing Pressure, Lb. per Sq. In.	Remarks
21	Logan.......	Chapmanville	1.64 mi. S. of 37°55′	4.34 mi. W. of 82°00′	3,933	Pen-Kanawha	M. Dev-Marcellus	Columbian Carbon	Island Creek Coal Co., 4-GW 752	0	0.084	430 (24 hr.)	Brown Shale gas well
22	Mingo......	Hardee	4.28 mi. S. of 37°50′	2.32 mi. W. of 82°05′	4,581	Pen-Kanawha	M. Dev-Marcellus	United Carbon Co.	Cotiga Dev. Co., 3-1124	0	0	0	Dry through Brown Shale
23	Putnam.....	Union	1.43 mi. S. of 38°40′	1.28 mi. W. of 81°45′	2,963	Perm-Dunkard	L. Mis-Pocono	Godfrey L. Cabot, Inc.	J. L. McLean Hrs., 28-1103	0	0	0	Dry through Berea
24	Putnam.....	Curry	4.29 mi. S. of 38°25′	0.30 mi. W. of 81°55′	4,341	Pen-Conemaugh	M. Dev-Marcellus	Reishman O. & G.	G. W. Miller, 1	0	0.150	540 (16 hr.)	Brown Shale gas well
25	Putnam.....	Pocatalico	0.65 mi. S. of 38°30′	1.79 mi. W. of 81°45′	2,012	Pen-Monongahela	L. Mis-Pocono	Cumberland Gas Co.	Raymond City Coal & Trans. Co., 1-CKP 10	0	0	0	Dry through Big Injun
26	Raleigh.....	Slab Fork	0.77 mi. S. of 37°40′	2.80 mi. W. of 81°15′	2,939	Pen-New River	L. Mis-Pocono	Godfrey L. Cabot, Inc.	Beaver Coal Co., 16-1093	0	0.026	0	Maxton gas show; abandoned
27	Raleigh.....	Slab Fork	4.62 mi. S. of 37°40′	0.50 mi. W. of 81°15′	3,770	Pen-Pocohontas	L. Mis-Pocono	Godfrey L. Cabot Inc.	Piney Coking Coal Land Co., 1-1106	0	0.372	420 (72 hr.)	Maxton & Weir Sand gas well
28	Raleigh.....	Marsh Fork	3.11 mi. S. of 37°55′	0.62 mi. W. of 81°25′	3,230	Pen-Kanawha	L. Mis-Pocono	Columbian Carbon	Rowland Land Co., 5-GW	0	0	0	Dry through Berea
29	Raleigh.....	Marsh Fork	4.38 mi. S. of 37°55′	2.92 mi. W. of 81°20′	2,258	Pen-Kanawha	U. Mis-Bluefield	Columbian Carbon	Rowland Land Co., 6-GW-737	0	0.848	595 (4 days)	Maxton gas well
30	Raleigh.....	Richmond	3.25 mi. S. of 37°50′	4.62 mi. W. of 80°50′	6,397	U. Mis-Hinton	L. Dev-Oriskany	Godfrey L. Cabot Inc.	C. E. Gwinn, 1-1115	0	0.015	0	Oriskany gas show aband.
31	Tucker......	Dry Fork	0.24 mi. S. of 39°05′	3.53 mi. W. of 79°20′	8,036	L. Mis-Pocono	L. Dev-Oriskany	Ohio Oil Co.	W. Va. Power & Transmission Co., 1	0	0.120	3200 (24 hr.)	Oriskany gas well
32	Upshur......	Buckhannon	4.88 mi. S. of 39°05′	0.33 mi. W. of 80°15′	4,426	Pen-Conemaugh	U. Dev-Chemung	Hanley & Bird	M. Edmiston, 1-1060	0	0.133	1500	Benson gas well
33	Wayne......	Lincoln	2.30 mi. S. of 38°00′	2.64 mi. W. of 82°20′	3,398	Pen-Kanawha	M. Dev-Marcellus	Owens-Libbey-Owens	Wilson Coal Land Co., 32-634	0	0.150	493 (62 hr.)	Brown Shale gas well
34	Wayne......	Butler	3.75 mi. S. of 38°15′	2.13 mi. W. of 82°30′	3,717	Pen-Conemaugh	Sil-Niagara	United Carbon Co.	Robert Rayburn, 1-1140	0	0.152	1210 (48 hr.)	Newburg gas well
35	Wayne......	Stonewall	4.00 mi. S. of 38°15′	2.73 mi. W. of 82°15′	3,133	Pen-Allegheny	M. Dev-Genesee	United Fuel Gas	Hungtington Dev. & Gas Co., -5421	0	0.103		Brown Shale gas well
36	Wood.......	Harris	4.74 mi. S. of 39°15′	1.17 mi. W. of 81°40′	4,507	Perm-Dunkard	L. Dev-Oriskany	W. Va. Gas Corp.	Peter Seebaugh, 1-519	0	0.082	580 (48 hr.)	Brown Shale gas show; abandoned. Dry in Oriskany
37	Wood.......	Harris	4.05 mi. S. of 39°15′	2.72 mi. W. of 81°40′	4,126	Perm-Dunkard	M. Dev-Marcellus	W. Va. Gas Corp.	B. H. Tennant, et al, 1-524	0	0.025	0	Brown Shale gas show; abandoned
38	Wyoming....	Oceana	5.54 mi. S. of 37°50′	3.94 mi. W. of 81°30′	1,983	Pen-Kanawha	U. Mis-Princeton	Hope Natural Gas Co.	Loup Creek Colliery Co., 2-8868	0	0.959	350 (12 hr.)	Princeton gas well
39	Wyoming....	Center	2.42 mi. S. of 37°40′	3.53 mi. W. of 81°25′	3,136	Pen-New River	L. Mis-Greenbrier	Godfrey L. Cabot, Inc.	Pocahontas Land Co., 5-1139	0	1.055	665 (21 hr.)	Big Lime gas well
40	Wyoming....	Slab Fork	2.48 mi. S. of 37°40′	2.18 mi. W. of 81°25′	1,607	Pen-New River	L. Mis-Princeton	Godfrey L. Cabot, Inc.	Pocahontas Land Co., 6-1145	0	0.467	360 (20 hr.)	Princeton gas well

Raleigh each had one dry hole. In Tucker County a gas well with heavy rock pressure was completed and may bring into production the huge Blackwater anticline, where there is a very large closed dome. In Wayne County two tests were dry in the Oriskany, and in Wood there were five failures. (For completed Oriskany wildcats see Table 3).

In the Charleston field, as summarized in Table 4, drilling was perfunctory, although the possibility of various extensions still exists. The total production in this field has been about 600 billion cu. ft., of which about 44 billion were taken out in 1944.

Three wells were drilled to the Newburg sand (Sil.), one of which, in Boone, was dry. The others are in Wayne, one of which extends southwestward for 1½ miles, the Butler district producing area. One well in Boone reached the "Clinton," or White Medina (Sil.), but was dry.

Development in the Big Lime

Important development occurred in the Big Lime, or Greenbrier (L. Mis.), in southern West Virginia. Pool extensions occurred in Kanawha, Lincoln, Putnam, Raleigh, Wayne and Wyoming; and new pools were opened in Logan and Nicholas Counties. This formation presently offers the best hope of substantial quantities of new gas, because its known or probable porous area includes a million or more acres where little drilling has been done.

Operating Technology

In addition to routine production methods, secondary recovery of oil by gas or gas-air injection, and the acidization of lime formations for increased oil and gas continued to have good results. One water-flood recovery project was started. Storage of natural gas in depleted pools near trunk pipe lines or heavy consuming

Table 4.—*Oriskany Sand Wells, Jackson and Kanawha Counties and Adjacent Part of Putnam County, West Virginia*

County and Magisterial District	Completed before 1944				Completed in 1944				Total Number of Completed Wells	Number of Wells Drilling or Unreported Jan. 1, 1945
	Gas Wells		Dry in Oriskany	Total Number of Wells	Gas Wells		Dry in Oriskany	Total Number of Wells		
	Number of Wells	Gas, M Cu. Ft.			Number of Wells	Gas, M Cu. Ft.				
Jackson County:										
Grant	3	829	0	3	1	2,500	0	1	4	1
Ravenswood	61	289,089	9	70	5	7,157	1	6	76	4
Ripley	233	1,226,759	11	244	6	12,703	3	9	253	2
Washington	64	453,416	10	74	1	862	1	2	76	1
Total	361	1,970,093	30	391	13	23,222	5	18	409	8
Kanawha County:										
Big Sandy	0	0	1	1	0	0	0	0	1	0
Cabin Creek	0	0	3	3	0	0	1	1	4	0
Charleston	1	88	0	1	0	0	0	0	1	0
Elk	92	376,211	13	105	1	10,000	1	2	107	0
Jefferson	0	0	1	1	0	0	0	0	1	0
Loudon	0	4,304	5	14	2	408	0	2	16	1
Malden	35	73,181	5	40	0	0	0	0	40	0
Poca	373	2,482,489	8	381	0	0	0	0	381	2
Union	25	4,933	5	30	1	1,286	0	1	31	1
Washington	1	254	3	4	0	0	0	0	4	0
Total	536	2,941,460	44	580	4	11,694	2	6	586	4
Putnam County:										
Union	18	29,769	2	20	1	1,186	0	1	21	0
Grand Total	915	4,941,322	76	991	18	36,102	7	25	1,016	12

centers has become a standard practice with the larger utilities.

Pipe Lines, Compressor Stations and Markets

As of Oct. 30, 1944, Tennessee Gas and Transmission Co. completed its gas transmission line from Texas to Cornwell Station, Kanawha County, W. Va., and immediately began delivery of about 200,000,000 cu. ft. daily. At Kenova, W. Va., the output divides, approximately 50,000,000 cu. ft. going northward into Ohio and the remaining 150,000,000 cu. ft. continuing eastward to Cornwell through a newly completed 18-in., 72-mile line. From Cornwell the gas goes northward through lines of Hope Natural Gas Co. to Hastings Station, Wetzel County. From Hastings, Hope built 18 miles of 12¾ in. o.d. line to the Pennsylvania border where it connects with a similar line of New York State Gas Corporation for transmission northeastward. To carry the added load, Hope installed at Cornwell a 1000-hp. gas-driven compressor, and at Hastings 4000 hp. of steam-driven compressors and a 100,000-lb. per hr., steam boiler. This new supply of gas largely takes care of lowered Appalachian production and increased demand.

During the year, also, Hope rebuilt its Bridgeport Station, Harrison County, after its almost total destruction in the unprecedented June tornado. It also installed a diethylene glycol dehydration plant, of 35,000,000 cu. ft. capacity and 500 lb. pressure, at Bridgeport, and a similar plant of 60,000,000 cu. ft. capacity at Cornwell.

At Auburn, Ritchie County, Carnegie Natural Gas Co. built an 80-hp. gas-driven compressor. In Kanawha County, Columbian Carbon Co. formed a new 600-hp. compressor at Rocky Fork by moving to this point one 300-hp. unit from Grapevine station and another similar unit from Aarons Fork station. In Boone County, Owens, Libbey-Owens Gas Department added one 400-hp. unit to its Brushton station.

In Clay County, United Fuel Gas Co. installed a gas-repressuring project in the Grannys Creek oil pool, and in Kanawha County started a small-scale water-flooding project in the Blue Creek oil field. In the same region it built several miles of 10-in. gas line from Cobb station, Kanawha County, to Lewis station, Roane County. In Mingo County it built a 165-hp. compressor near Breeden.

In Wyoming County, Godfrey L. Cabot, Inc. completed installation of two 300-hp. compressors near Lester. In the same region this company built 18.5 miles of 6-in. gas line from the Pineville pool of Wyoming County to the Slab Fork pool of Raleigh.

Oil and Gas Prices

The posted price of oil remained at $2.59 per bbl. through the year, but on Aug. 1 a subsidy of $0.75 per bbl., to be paid by Defense Supplies Corporation, became effective on West Virginia oil. No appreciable stimulation of production has resulted, because the operators still consider the $3.34 per bbl. total return too low to justify exploration.

Figures are not yet available for the price of gas at the well mouth in 1944, but the U. S. Bureau of Mines figure of 12.3 cents per 1000 cu. ft. in 1943 is an advance of 0.1 cent over 1942.

County Summary

Table 5 shows by counties the new development in West Virginia during 1944. This information is compiled from all available sources, including trade journals, the West Virginia Department of Mines, the West Virginia Geological Survey, the special plat service offered by Veleair C. Smith Management, and from private reports.

The various reports do not altogether agree, but Table 5 attempts to reflect a

careful history of every well that was completed in West Virginia during 1944.

According to the Department of Mines, 1019 permits to drill were issued, as compared with 878 in 1943.

TABLE 5.—*Summary of New Development in West Virginia during* 1944

County	New Wells						Wells Drilled to Deeper Sands			
	Number of Wells	Oil Wells		Gas Wells		Dry Holes	Number of Wells	Production		Dry Holes
		Number of Wells	Bbl. per Day	Number of Wells	M Cu. Ft. per Day			Oil, Bbl. per Day	Gas, M Cu. Ft. per Day	
Barbour	8	0	0	8	2,826	0	0	0	0	0
Boone	65	3	36	53	37,000	5	4	0	935	0
Braxton	18	1	40	8	3,940	7	1	0	0	1
Brooke	5	1	10	0	0	0	4	9	0	0
Cabell	4	0	0	3	449	0	1	0	158	0
Calhoun	48	8	52	31	14,209	5	4	0	736	0
Clay	52	6	28	37	14,188	8	1	0	262	0
Doddridge	14	0	0	6	1,193	2	5	0	540	1
Fayette	1	0	0	0	0	1	0	0	0	0
Gilmer	64	4	35	36	21,431	7	14	2	2,215	3
Hancock	2	0	0	1	100	1	0	0	0	0
Harrison	11	2	4	3	363	1	5	0	646	0
Jackson	23	1	15	14	23,429	4	2	0	0	2
Kanawha	98	3	51	74	37,225	7	9	6	749	5
Lewis	18	0	0	4	598	6	6	0	199	2
Lincoln	103	4	23	74	20,517	1	23	0	3,592	1
Logan	17	0	0	15	12,115	2	0	0	0	0
Marion	12	1	15	4	530	2	5	0	255	0
Marshall	12	0	0	6	3,760	4	2	0	311	0
Mason	1	0	0	0	0	1	0	0	0	0
Mingo	12	1	12	5	1,097	2	2	0	0	2
Monongalia	9	0	0	2	466	2	4	0	210	1
Nicholas	7	0	0	7	15,738	0	0	0	0	0
Ohio	1	0	0	0	0	1	0	0	0	0
Pleasants	10	2	12	5	3,161	3	0	0	0	0
Preston	1	0	0	0	0	1	0	0	0	0
Putnam	39	0	0	24	21,877	10	4	0	551	1
Raleigh	16	0	0	8	5,978	8	0	0	0	0
Ritchie	35	5	19	19	4,123	7	3	0	338	1
Roane	18	11	49	5	2,670	2	0	0	0	0
Taylor	8	0	0	5	7,130	2	1	0	66	0
Tucker	1	0	0	1	120	0	0	0	0	0
Tyler	7	1	8	3	521	2	1	0	100	0
Upshur	48	0	0	33	8,568	14	1	0	93	0
Wayne	49	1	3	45	13,631	3	0	0	0	0
Wetzel	20	5	113	9	1,479	3	2	0	273	1
Wirt	12	2	30	4	3,607	3	3	5	98	0
Wood	28	9	58	5	7,482	14	0	0	0	0
Wyoming	21	0	0	20	13,851	1	0	0	0	0
State Total	918	71	613	577	305,372	142	107	22	12,327	21

ACKNOWLEDGMENTS

The writer is glad to acknowledge helpful information through the year from the following organizations and individuals: West Virginia Department of Mines, Miss Marie Griffith; West Virginia Geological Survey, Mr. R. C. Tucker; Public Service Commission of West Virginia, Mr. H. J. Wagner; U. S. Bureau of Mines, Mr. F. S. Lott; Carnegie Natural Gas Co.; Mr. H. L. Applegate; Columbian Carbon Co., Mr. R. B. Anderson; Godfrey L. Cabot, Inc., Mr. H. J. Simmons, Jr.; Hope Natural Gas Co., Mr. J. A. Clark; Owens, Libbey-Owens Gas Dept., Mr. A. H. McClain; Pittsburgh and West Virginia Gas Co., Mr. J. H. Newlon; Veleair C. Smith Management, Mr. John Galpin; Tri-State Oil and Gas Co., Mr. H. P. McGinnis; United Carbon Co., Mr. I. G. Grettum; United Fuel Gas Co., Mr. J. L. Steward; West Virginia Gas Corp., Mr. J. E. Billingsley. Miss Mary C. Bollinger, secretary to the author, handled many of the statistics on production.

Production in Arabia and Bahrein in 1944 with Summary of Operations Since 1940

By James Terry Duce,* Member A.I.M.E.

The gross production on the Island of Bahrein during 1944 was approximately 6,700,000 U. S. bbl. No additional wells were drilled in the field during the year, but a number that were plugged off during the critical days of the war were brought back on production. This work is continuing. The construction of the extension of the refining plant was continued during the year and the new crude still was started in November.

In Arabia, the production for the year 1940 was 5,074,838 U. S. bbl. Four wells were completed in Dammam field and all were commercial producers. Production for 1941 was 4,310,110 U. S. bbl. Seven more commercial producing wells were completed in Dammam field, and Well No. 1 at Abqaiq was completed at 6180 ft. and was also a commercial producer. In 1942 production was 4,530,492 U. S. bbl. Abqaiq No. 2 was drilled to 5785 ft. but was left standing because of mechanical difficulty. The 1943 production was 4,868,184 with one well drilled, Abqaiq No. 3 completed at 6488 ft. and a commercial producer.

Total production in Arabia for the year 1944 was around 7,800,000 U. S. bbl. and at the close of the year was running at approximately 40,000 bbl. per day. The small refinery, built in 1939, at Ras Tanura was in operation in the fall and a new refinery is being constructed. Only three wells were completed during the year—the El Jauf well in Northern Arabia (completed at 10,974 ft.) which did not bring in commercial production and Wells No. 4 (completed at 6270 ft.) and No. 5 at Abqaiq (completed at 6751 ft.), which were brought in as substantial commercial producers. Production for the year was entirely from the Dammam field. In this field, some of the wells that had been plugged off early in the war were brought back in production and this work is continuing. At the close of the year, one well was drilling in the Abqaiq field and an additional well was drilling at Qatif, the latter being a wildcat. Neither of the wells in question had reached producing horizons on the first of January.

Manuscript received at the office of the Institute April 12, 1945.

* Director and Vice-President, Arabian American Oil Co.

Petroleum Activities in Brazil in 1944

By S. Froes Abreu*

Official daily output of the Reconcavo (Bahia) oil fields, which amounted to 300 bbl., increased by the end of 1944 to 500 bbl. The new productive wells are in the district of Candeias. This figure is expected to further increase during 1945.

The Itatig Company, which had drilled five wildcats in the state of Sergipe, stopped in 1944, but intends to resume work during the current year, or as soon as the war is over, in order to try the Cretaceous areas around its salt deposits.

Several concessions applied for in the states of São Paulo, Parana and Santa Catarina were favorably considered by the Conselho Nacional de Petroleo, which is interested in fostering prospecting activities in the country.

Several national groups are interested in exploring the federal gas field of Aratu (Bahia), a proposal having been made to use the gas in the manufacture of Portland cement.

Undoubtedly the most important fact in the 1944 activities was the visit by two outstanding petroleum geologists, who had the opportunity to examine some of the principal areas and reported their opinions to the Brazilian Government.

By special courtesy of the U. S. Government, Mr. E. DeGolyer spent a few weeks inspecting the gas and oil fields of the so-called "Reconcavo" of Bahia (a large tract surrounding All Saints Bay, on whose shore lies the city of Salvador) Later he exchanged ideas with Colonel João Carlos Barreto, President of the Conselho Nacional de Petroleo, as to the most adequate measures to develop production.

Considering the oil problem in the southern part of Brazil, in the sedimentary belt including formations from the Devonian to the Triassic, Mr. DeGolyer suggested a visit there by Mr. Lewis MacNaughton.

The latter traveled during the months of June, July and August, accompanied by Brazilian geologists Avelino de Oliveira, Vice-president of the Conselho Nacional de Petroleo, Pedro Moura, Annibal Bastos, Burdot Dutra and J. Felicissimo, and verified the actual possibilities of the region, thus confirming the opinion of Pedro Moura, Avelino de Oliveira and Froes Abreu as to the advisability of thoroughly prospecting the south of Brazil.

It is to be hoped that on the recommendation of these proficient American experts the Brazilian Government will take the necessary measures to carry out a complete search of such areas, which hitherto have been unsuccessfully drilled because knowledge of the structure was not adequate. The old Government policy of monopolistic essence has now given way to the more enlightened tendency of reconciling official action with private enterprise, which should in no way be curbed but rather encouraged. Such trend is heartily welcomed by financiers and technicians alike, who realize how indispensable is the cooperation of private capital, both national and foreign, in

Manuscript received at the office of the Institute April 13, 1945.

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any scheme seeking large-scale production of basic commodities such as petroleum, iron and steel or fertilizers.

At the recent Economic Conference held per cent in mining enterprises, is a good step toward a liberal policy, which will open good opportunities for foreigners in Brazilian business.

FIG. 1.—OIL FIELDS, RECONCAVO AREA, STATE OF BAHIA, BRAZIL, 1945.

in São Paulo the idea was raised of a special code for investment of foreign capital, regulating the benefits on capital with a view to common interests of native and foreign investors.

Decree No. 6230, of Jan. 29, 1944, allowing foreign investment up to 50

All who have studied the oil possibilities in Brazil have arrived at favorable conclusions provided a complete and systematic plan of survey is laid out and followed and disorderly wildcatting is avoided.

Scattered and uncoordinated search cannot lead to good results except by

sheer luck, which cannot be reckoned with. Lack of knowledge of subsurface conditions in all supposed petroliferous areas is the general rule in Brazil, where the number of wells drilled is insignificant. During 1944 only the Government was active in drilling and it concentrated its attention on the "Reconcavo" of Bahia. Throughout the national territory not a single well was drilled by private parties. Acre and Lower Amazon regions remained untouched, also the Atlantic coast line north of Bahia. In the state of Piaui the Servico de Fomento da Producao Mineral drilled a deep hole in a search for coal in the lower Carboniferous (Westphalian). It struck sulphydric water and vestiges of Carboniferous flora. In South Brazil geological surveys were made, and private parties applied for authorization for exploration in the states of São Paulo, Parana and Santa Catarina.

Considerable attention had been given to these southern areas before Mr. MacNaughton's arrival, but no doubt his visit spurred such interest.

Table 1.—*Brazilian Oil Production*

Year	Official	Calculated	Barrels
	Cubic Meters	Metric Tons	
1940	332	272	2,093
1941	496	406	3,216
1942	5,285	4,332	34,259
1943	7,656	6,275	48,506
1944	9,148	7,498	57,960 or 161 per day

Among others, Froes Abreu has studied the superficial indications found in sandstones of Botucatu (state of São Paulo), in the Triassic of Rio do Rasto, in Carboniferous sandstones of Tubarao-Itarare, and in the basic eruptives covering wide areas in southern Brazil.

In a communication to the Academia Brasileira de Ciencias, Prof. Fernando de Almeida of the São Paulo University announced this year the discovery of formations of the Itarare series (glacial facies of the Carboniferous) in the territory of Ponta Pora, south of the state of Matto Grosso. This new contribution to the knowledge of the petroleum geology in south Brazil extends the possibility of petroliferous areas farther westward.

Modern geochemical technique, if applied to certain areas of Brazil where superficial indications of bitumen and small gas seepages are known, might bring important guidance to the always delicate problem of well locations. Froes Abreu suggested to the Government a test of such technique, which might bear very important results provided it was applied in conjunction with adequate structural studies. Until a few years ago, in Brazil all work on petroleum was kept under strict secrecy, without disclosures, even to technicians, that might incite new researches.

Decree No. 6230, and other alterations to the Mining Code now being considered by the Conselho Nacional de Petroleo, aim at making it easier for those who will be willing to contribute to the development of oil exploration in Brazil, and offer them greater guarantee, and point to an era of large prospecting activity ahead.

During 1944 no progress was made in distillation of oil shale. The plants already working maintained the same trend. Guarei plant, dealing with bituminous sandstones in the S.E. of São Paulo (Municipality of Guarei), kept its daily output of 25 bbl. Anticipating difficulty when imports of gasoline, kerosine and diesel oil will be possible, the company started extraction of bitumen from the sandstone by a process employing hot water and soda ash, and has already produced substantial quantities, which are readily absorbed by the local market. The deposits are lenses of more than one million tons of bituminous sandstone containing 5 to 12 per cent bitumen with 30 per cent asphaltene and 70 per cent petrolene.

A small plant of an experimental type is working in S. Matheus, state of Parana, using black oil shale of the Iraty formation. Its output is only 2 to 3 bbl. per day, and the crude oil redistilled yields gasoline, kerosine, diesel oil and mazout, all consumed locally.

An area in the basaltic plateau in Santa Catarina showing seepages of a black asphaltic oil in a cracked melaphyre deserves special attention. This oil possibly originates from layers of Botucatu or Piramboia sandstone, which in São Paulo shows great masses of bitumen in the outcrop, but in Santa Catarina is covered by a thick sheet of melaphyre.

Petroleum Developments in Canada, 1942–1944

By G. S. Hume*

During the war years the drilling activity in Canada has been steadily increasing and still further increase is expected in 1945. The production of oil, which in the past has come largely from the Turner Valley field in Alberta, shows a decline since 1942, the peak year. New discoveries made in 1944, however, give promise of replacing the decrease from Turner Valley where the crude-oil production in 1944 was nearly 1,800,000 bbl. less than in 1942, but with an increase of 145,000 bbl. in natural gasoline, a product of great value to the war effort. A very considerable part of the decline in Alberta has been offset by new production of more than a million barrels in 1944 from the Norman Wells field, in the Mackenzie River area of the Northwest Territories. It should not be forgotten, however, that this is largely due to the Canol development, a war project, the future of which is dependent on many factors not connected with an ordinary commercial operation.

The year 1944 has been the best in new discoveries in Alberta for all time. The discovery of a new deep field at Jumpingpound, 20 miles west of Calgary, with the hope of a type of product similar to that of Turner Valley is the culmination of many years of effort to interpret the subsurface structures in relation to the complicated surface foothills faulting and folding. In this case the subsurface structure on the Paleozoic limestone was inferred from geological investigations but precisely defined by seismograph. In addition to Jumpingpound the discovery of oil of 34.5° gravity at a depth of less than 5000 ft. in the Devonian of the Plains at Princess, 125 miles east of Calgary, is of great significance since this is the first substantial production from the Devonian in Alberta, although previously some oil had been obtained at two places from the Devonian in the foothills. The effect of this discovery is already apparent in the number of wells now drilling to the Devonian in the southern Plains.

In southern Alberta a new producing area has been found in a Lower Cretaceous sand at Barnwell, a few miles west of Taber. Also, at Conrad, 20 miles southeast of Taber, an important new discovery has been made at a depth of about 3000 ft. in a sand in Jurassic shales, in a stratigraphic trap on the northeast flank of the Sweetgrass arch.

In northeast Central Alberta an important extension has been found in the Lloydminster area, where only a few wells have so far been drilled. A new well 3½ miles south of the previous producers found a coarser sand at the productive horizon and as a result will have an increased daily yield. At Blackfoot, 9 miles west of Lloydminster, a new producing area in the Lower Cretaceous may have been discovered at a depth of 2004 ft. At the end of 1944 the well was being tested.

Forty-four unsuccessful wildcat wells were drilled in Alberta in 1944.

The decline of Turner Valley, the major producing field, was anticipated at the beginning of the war and in an effort to offset this and encourage new development the Dominion Government put into force tax concessions and other measures that,

Manuscript received at the office of the Institute April 12, 1945.

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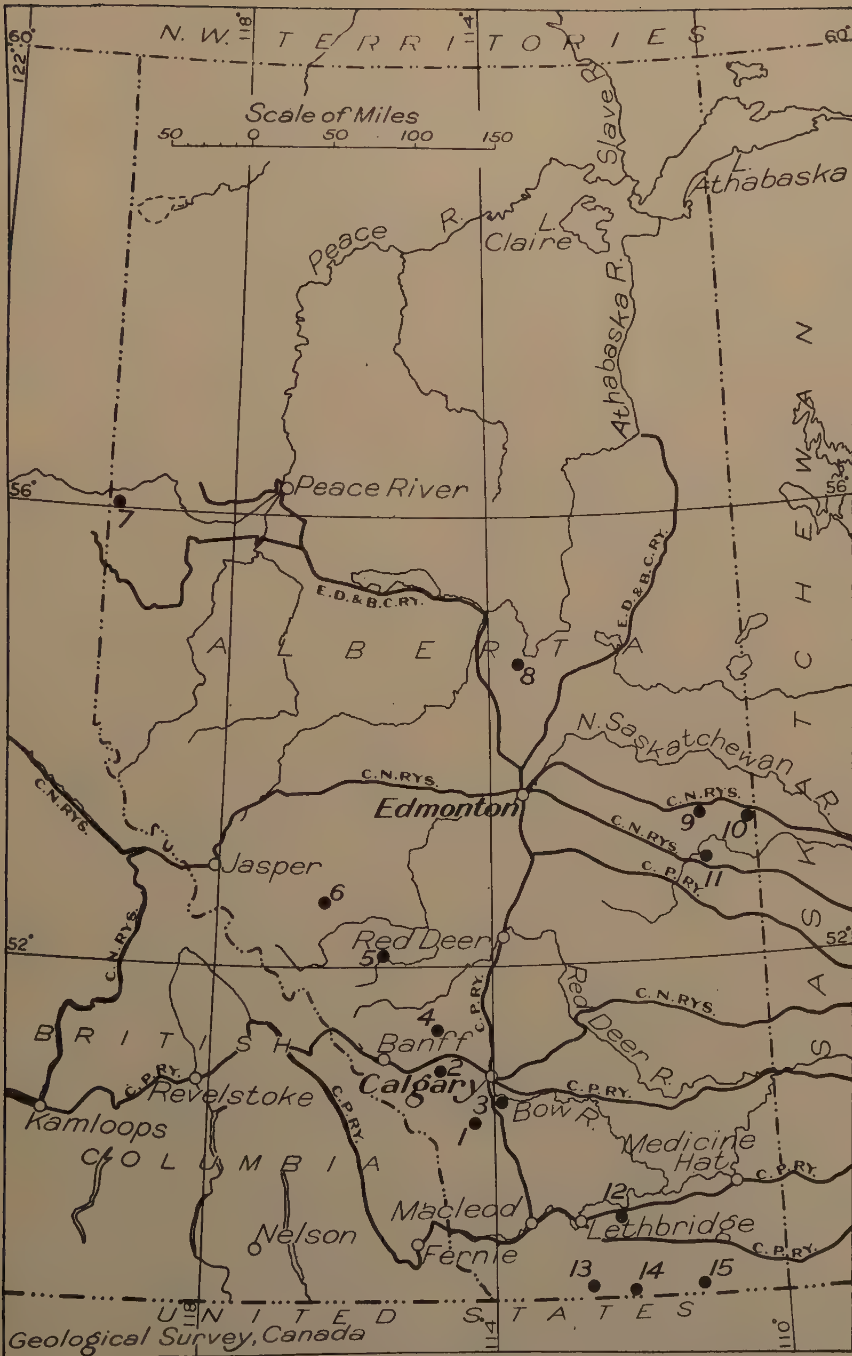

Fig. 1.—Oil and gas fields of Alberta and Saskatchewan.

judging by the activity in the last few years both in exploration and drilling, have been highly effective. Also, to offset the decline, a Crown Company—Wartime Oils—was formed in 1943 for the loaning of money to operators to drill wells on the west flank of Turner Valley, on sites that were considered marginal in respect to economic operations. At the end of 1944 the contemplated drilling program was finished with the successful completion of 21 wells out of 22 drilled. The average depth of the wells was 7868 ft. and all were in the productive area where the yield is related to the amount of porosity and permeability in the producing Paleozoic limestone. The one failure was the result of finding inadequate porosity to yield oil. The success of the operation under the Wartime Oils program may be judged from the production of 50,669 bbl. in November 1944; or an average of 1689 bbl. a day from 20 wells.

TABLE 1.—*Petroleum Production in Canada*
BARRELS

Province	1942	1943	1944
New Brunswick[a]	28,089	24,530	22,972
Ontario[b]	143,845	132,492	125,067
Alberta[c]	10,136,296	9,674,548	8,788,845
N. W. Territories	82,324	266,882	1,229,324
Total	10,390,554	10,098,452	10,166,208

[a] Bureau of Statistics, Ottawa.
[b] Natural Gas Commissioner, Ontario.
[c] Petroleum and Natural Gas Conservation Board Alberta.

TABLE 2.—*Petroleum Production in Alberta*
BARRELS

Field	1942	1943	1944
Turner Valley:			
Oil wells	9,621,326	8,940,198	7,837,492
Gas wells	74,587	46,465	37,427
Shallow oil wells	5,802	4,865	3,209
Natural gasoline	302,216	461,169	448,186
Total	10,003,935	9,452,697	8,326,314
Red Coulee	10,107	8,928	3,835
Wainwright	14,510	18,136	17,154
Vermilion	56,819	93,258	234,666
Taber	29,819	88,735	148,694
Lloydminster	477	2,640	6,296
Princess	10,478	340	13,815
Conrad			24,733
Miscellaneous areas	10,151	9,814	13,338
Total	132,361	221,851	462,531
Grand Total	10,136,296	9,674,548	8,788,845

One of the interesting features of activity, stimulated by the war and consequent Government concessions, has been the renewed search for oil in the eastern provinces of Canada; in Gaspé, Quebec, in Nova Scotia and in Prince Edward Island in the St. Lawrence. This search is being continued and definite results ought to be available in 1945.

The production of petroleum for Canada and for Alberta, the major producing province, is given in Tables 1 and 2.

TURNER VALLEY

Two recent developments in Turner Valley are of considerable significance in relation to the further expansion of this field. The first of these was the discovery by drilling in 1943 that the fault that cuts off Turner Valley on the east side extends as a low-angle fault under the structure and even on the west flank cuts above the Devonian limestone thus eliminating the possibility of deeper production in the Turner Valley structure, that is above the thrust fault. The second was a small extension of Turner Valley opened in 1943 on the east side at the north end of the field. This is in a fault block lying in front of the main limestone mass and at a considerably lower elevation. The relationships seem to indicate that this fault block was cut off and depressed after the oil had accumulated and that the oil in the fault block was carried down with it in the faulting adjustments. In 1944 continued drilling in this fault block was disappointing and the size of the block, as far as it has been outlined, appears to be small.

In 1944 there has been some extension of Turner Valley to the northwest, where the structure is a series of fault blocks thrust over one another. Any considerable further extension is rather uncertain and future drilling will be dependent on the

interpretation made as each new well is completed. In the south end also the limits of the field were more closely defined by a well drilled in 1944. Only one further well is at present drilling in this area and there seems little hope of any further extension.

The number of successful completions in Turner Valley in the past three years were as follows: 29 in 1942; 23 in 1943; 38 in 1944. Wartime Oils sponsored 18 wells drilled in Turner Valley in 1944 and of these 17 were successful. This accounts for the increase in completions for this field in 1944. A sharp decrease in the number of completions is anticipated in 1945, in that relatively good drilling sites are becoming scarce and edge locations are somewhat more hazardous.

Jumpingpound Area

Drilling has been done in the Jumpingpound area at intervals, but particularly since 1926. There is a well-marked faulted fold on the surface and most of the past drilling was directed toward testing this. In 1944, however, the Shell Oil Co. drilled a well beginning in the Jumpingpound fault plate but passing through it to test a fold lying under its eastern edge. As the fault that cuts off the Jumpingpound fold is considered the structural division between the foothills and the plains, it will be apparent that the well started drilling within the foothills structural belt, but that the structure at depth may be considered rather as belonging to the Plains. It may be, however, that it may not be a simple anticlinal fold such as occur farther east.

The Jumpingpound well reached the top of the Mississippian limestone at a depth of 9618 ft. and was completed at 9947 ft. with a flow of gas and light oil. After acidization, the well made 13,500 M cu. ft. through the tubing and slightly less than 100 bbl. of oil (47° to 52° A.P.I.) a day, the gravity of the oil being dependent on the back pressure. The bottom-hole pressure is said to be about 3900 lb. The next well will be drilled down the flank in the hope of obtaining crude oil as in Turner Valley.

Princess Area

Several wells were drilled in the Princess area, about 125 miles east of Calgary, between 1939 and 1942, and one of these, Standard Princess No. 2, obtained some oil from the upper part of the Mississippian limestone. No success was obtained by further operations until 1944, when Princess, C.P.R. No. 18-21A (formerly known as Princess No. 8), found production of 34.5° gravity oil in the Devonian at a depth of 3965 to 3982 ft. The top of the productive zone is 345 ft. below the top of the Devonian and about 50 ft. below the top of a limestone that underlies a succession of anhydrite beds. The well was placed on production on Sept. 17, but was not produced steadily because of lack of storage facilities. The production to the end of October was 5167 bbl. and in November and December was 3652 and 2937 bbl., respectively.

This discovery has great significance and importance, since the Devonian has the widest extent in western Canada of all the Paleozoic rocks.

Norman Wells Area, Northwest Territories

The development of the Norman Wells field, in the Mackenzie River area of the Northwest Territories, was part of the Canol project inaugurated as a result of military necessity in 1942. At the beginning of operations there were four wells, the discovery well of which had been drilled in 1920. In 1942, under the Canol project, 16 more wells were drilled, and because the oil in the discovery well came out of beds higher than the main reservoir rock, a coral reef of Upper Devonian age, 12 of these wells drilled in 1942 were reworked and deepened in 1943. All of these wells

were on the northeast bank of Mackenzie River, including the discovery well.

In 1943, in addition to the wells that were reworked, 12 new wells were drilled, and where a well drilled in 1923 had given a good oil show, and three are on Goose Island, a low sand bar only partly above high water level, north of Bear Island.

TABLE 3.—*Oil and Gas Production in Alberta and Northwest Territories*

Line Number	Place[a]	Year of Discovery	Area Proved, Acres[b]: Oil (Drilled)	Area Proved, Acres[b]: Gas	Total Oil Production, Bbl.[c]: To End of 1944	Total Oil Production, Bbl.[c]: During 1944	Total Gas Production, Millions Cu. Ft.[e]: To End of 1944	Total Gas Production, Millions Cu. Ft.[e]: During 1944	Number of Oil and/or Gas Wells: Completed to End of 1944	During 1944: Completed	During 1944: Abandoned	End of 1944: Temporarily Shut Down	End of 1944: Producing Oil	End of 1944: Capable of Producing Gas
1	Turner Valley	1924	10,520	10,000	73,707,960	8,326,314[1]	1,328,377	40,298	404	38	5		255	60
2	Taber	1942	230		292,266	148,694[2]			7	3		1	6	7
3	Conrad	1944	120		24,733	24,733			3	3			3	3
4	Red Coulee[4]	1929	70		328,731	3,855		Small	7	0	5		0	
5	Vermilion	1939	560		417,813	234,666		Small	57	12	0	10	47	

Line Number	Oil Production Methods End of 1944, Number of Wells: Flowing	Artificial Lift	Reservoir Pressure Lb. per Square Inch: Initial Gas Area at End of 1944	Character of Oil[i]: Gravity A.P.I. at 60°F. Weighted Average	Producing Formation: Name and Age[f]	Character[h]	Porosity, Per Cent[l]	Depth, Avg. Ft.: Top of Producing Zone	Depth, Avg. Ft.: Bottom of Producing Zone	Net Thickness, Avg. Ft.	Structure[e]	Deepest Zone Tested to 1944: Name	Depth of Hole, Ft.
1	254	1	2,000+	42	Rundle, Mis	LS	Por	7,340	7,840	120 to 150 ft.	AF	Mis	8,795
2		Pump		18	Blairmore equivalent, CreL	S	Por	3,136	3,176	40	ML	Mis	3,233
3		Pump		25	Ellis, Jur	S	Por	2,965	2,970[3]	2 wells 5 and 10 ft.	ML	Mis	3,234
4				31	Blairmore equivalent, CreL	S	Por	2,450	2,482	32	T	Mis	2,765
5		Pump		14	Lower Cre, CreL	S	Por	1,820	1,828	8	H	Dev	2,306

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Includes natural gasoline.
[2] Includes production from Plains Nos. 1 and 2 wells.
[3] Discovery well.
[4] Field now abandoned.

of which 11 were producers. Four of these are on the northeast bank of Mackenzie River, five are on Bear Island, which is about 1¼ miles from the northeast bank,

In 1944, 30 wells were drilled in the proven area, bringing the total number of wells drilled in and immediately adjoining the proven area to 62, of which 58 found

oil in commercial quantities. Discovery No. 1 well, drilled in 1919 on the updip side of the field, was abandoned in 1944 because it had not been drilled to the main reservoir rock and had gone largely to gas. No. 18X well, also on the updip side of the field, is now being used as a gas-intake well for returning excess gas to the formation. There are thus 56 wells in the field at present capable of producing oil. The depth of the wells is 1050 to 1150 ft. on the updip side to 2000 ft. on the downdip side. Oil was started in the pipe line to Whitehorse, 598 miles distant over the Mackenzie mountains, in December 1943.

Drilling of wildcat wells to test other structures in the Mackenzie basin has so far been disappointing. The search for new oil fields was partly carried out under the Canol project but largely as an Imperial Oil exploration. The difficulties of obtaining satisfactory geological information in the interstream areas, which are largely covered with muskeg, should be kept in mind and for this reason some of the wildcat locations have been drilled on structures for which the information on the closure in one direction was not as satisfactorily determined as ordinarily it would be. To date most of the wildcats drilled have been relatively shallow, and deepening at least one or two of them is planned. The wildcat wells that have been drilled are within an area 50 miles upstream (Bluefish Creek) to 75 miles downstream (Sans Sault Rapids) from the Norman Wells field.

Saskatchewan

Imperial Oil Company Limited and Norcanols, in which Imperial Oil is largely interested, have had a large exploration and drilling program in southwestern Saskatchewan since 1940. Large areas have been examined geologically, supplemented by core drilling and by gravimeter and seismic surveys. Drilling commenced in 1942 and since that time eight deep tests have been made and two were drilling at the end of 1944. One of these deep tests drilled the complete Paleozoic section and encountered the top of the pre-Cambrian at 9395 ft. Some shows of oil have been reported but no discoveries have been made.

Eastern Canada

The decline in oil production continues in Ontario where the drilling is now largely directed toward maintaining a supply of natural gas.

In the Stony Creek field of New Brunswick there have been no recent extensions but there was some improvement in oil production in 1942 over previous years. This increase, however, is not being maintained and production is very small.

Prince Edward Island, in the Gulf of St. Lawrence, to the northeast on the trend of sediments that produce oil in New Brunswick, has been considered a deep potential source of production for many years. In 1943 a well was commenced on a pier built in Hillsborough Bay by the Island Development Co., a joint venture of Socony Vacuum and Cities Service Oil companies. The well was suspended late in 1944 on account of difficulties of winter drilling. It is now more than 11,600 ft. deep and still in beds considered to be non-marine Pennsylvanian.

In Nova Scotia, the Lion Oil Refining Co. drilled a well in the Mabou area of Cape Breton Island in 1944, east of the Lake Ainslie district, where seepages of oil occur. The first well, Mac No. 1, was abandoned at 5579 ft. after drilling a succession of red and gray shales with gypsum throughout. A second well, Mary No. 1, about ¾ mile northwest of the first, is now drilling.

In Gaspé, Quebec, Imperial Oil Co. drilled two wells between 1939 and 1942. The first of these, Mississippi No. 1, in Larocque township about ¾ mile east of the southern end of Dartmouth lake,

reached a depth of 5995 ft. Limestones were drilled for the whole depth, the upper part to 4980 ft. being Lower Devonian and the lower part from 4980 ft. to the bottom either Lower Devonian or Silurian. Beginning in December 1941 and completed in 1942, a second well was drilled in Douglas township to a depth of 4779 ft. The whole of the section drilled was Middle Devonian sandstones and shales and the Lower Devonian limestones were not reached. No production was found.

In 1943 Continental Petroleums Limited commenced drilling in Galt township. The No. 1 well is at present standing at a depth of 2137 ft. but drilling is not completed. The well is on a dome of Lower Devonian limestones surrounded by Middle Devonian sandstones. A show of gas occurred at 833 ft. and a show of oil at 847 ft. A second well, about 4½ miles west and slightly south of No. 1, was commenced in January 1944 in the Middle Devonian sandstones. At the end of 1944, the well was at a depth of 2556 ft., three porous zones of low permeability having been encountered in the underlying limestones at 2072 to 2127, 2162 to 2189, and 2338 to 2360 ft. These have given shows of oil and attempts are being made to acidize them to obtain production. This well is close to Petroleum Oil Trust No. 20 well, drilled in 1896, from which a little oil still flows. Geological explorations by this company were continued in 1944 and a new location will be made in 1945 on the Galt anticline, about 3½ miles northeast of No. 1 well.

It has long been recognized that the main essential to obtain oil in commercial quantities is the discovery of a porous reservoir rock, so far lacking in Gaspé. Oil shows occur in the wells and oil seepages are present. Favorable structures are known. The proposed new well on the Galt anticline has the objective of testing a sand that occurs about 365 ft. in the Lower Devonian limestones and known to have a seepage where the limestones crop out beyond the syncline that lies to the northeast of the Galt anticline.

Petroleum Developments in Colombia, 1942–1944 Inclusive

By O. C. Wheeler,* Member A.I.M.E.

The reports for the years 1942 and 1943 were written in 1943 and 1944, respectively, and were summarized at the meetings of the Institute in February of those two years, but the manuscripts were held until released for publication in 1945.

1942

Lack of transportation facilities during 1942 resulted in a sharp curtailment of producing operations in Colombia at the middle of the year, and production of crude for export was thus greatly affected. Total production in 1942 amounted to only 10,617,008 bbl. Of this amount the Tropical Oil Co. produced 9,453,995 bbl., which includes 126,607 bbl. of petroleum condensate, and the Colombian Petroleum Co. produced 1,163,013 bbl. from its Barco property. The following summary, showing a comparison of the number of barrels of crude produced during the years 1941 and 1942, reflects the extent to which producing operations were reduced during 1942:

Company	1941	1942
Tropical Oil Co.	20,785,309	9,453,995
Colombian Petr. Co.	3,942,525	1,163,013
All Colombia	24,727,834	10,617,008

These above figures do not include any production recovered from Condor's (Shell's) Casabe wells during testing operations.

An active exploratory drilling program was carried out by several of the major companies, and the year 1942 established a record for wildcatting activity in Colombia. Excluding development operations on the Shell's Casabe wells on the Yondo concession, 13 wildcats were completed. Eight of these were in the Magdalena Valley, and all were abandoned; five were on the Barco Concession, and of these four were completed as producers.

Particularly notable among the petroleum developments during 1942 was the continued success of drilling operations on the Shell's Yondo Concession of Compania Colombiana de Petroleos El Condor opposite Barranca-Bermeja. In 1941 the discovery well, Casabe No. 1, was drilled and completed with an estimated initial production of approximately 480 bbl. of 19½ A.P.I. gr. oil per day. In 1942, seven stepouts from the discovery well were successfully completed with initial production ratings ranging from 150 to 1230 bbl. per day.

An extensive wildcat program on the Barco Concession of the Colombian Petroleum Co. yielded favorable results with the completion of four producers in the Socuavo and Tres Bocas areas; a fifth test, Sardinata Norte No. 1, was abandoned at 5005 feet.

Wildcatting operations in the lower Magdalena Valley area were initiated in 1942 with the drilling of a deep test, El Doce No. 1, by Compania de Petroleo Shell de Colombia. The well was a failure and was abandoned at a depth of 10,046 (?) feet.

Wildcats on which drilling operations were being conducted at the end of the

Manuscript received at the office of the Institute April 13, 1945.

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year numbered 5, as shown in the accompanying table.

Wildcats Uncompleted at End of 1942

Well	Company	Concession
Cantagallo No. 2.	Cia. de Petroleos del Valle del Magdalena	Cantagallo
Braval No. 3.	Cia. Colombiana de Petroleo Sierra Nevada, S.A.	Camacho Roldan
El Dificil No. 1	Cia. de Petroleo La Estrella de Colombia	El Dificil
El Brillante No. 1.	Cia. de Petroleo Shell de Colombia	El Doce
Socuavo No. 3....	Colombian Petroleum Co.	Barco

An authoritative report on the status of applications for national petroleum concessions and a recapitulation of all applications submitted for petroleum concessions under Petroleum Law No. 37 of 1931 and Law No. 160 of 1936, appeared in the Annual Report of the Minister of Mines and Petroleum in July 1942. According to this summary, 120 applications for petroleum concessions had been presented from 1931 to June 1, 1942 and of these 67 were accepted. The area covered by the applications accepted totaled 2,900,024 ha. Several of these accepted applications were terminated, for one reason or another, before contracts for concessions had been granted. The area thus abandoned totaled 321,345.6 ha., which left a total area of accepted applications of 2,578,678.4 hectares.

Two articles of interest on the petroleum developments in Colombia appeared in the trade journals during the year under the authorship of Dr. Eduardo Ospina-Racines.*

Operating Companies

Colombian Petroleum Company

Operations were continued by the Colombian Petroleum Co. on its Barco concession during 1942. Wildcat drilling resulted in the completion of four new producers in the Socuavo and Tres Bocas areas. Producing operations were drastically curtailed, and total production during the year amounted to 1,163,013 bbl., or an average of 3186 bbl. daily, as compared with a daily average of 10,801 bbl. in 1941.

Socuavo Well No. 1 was drilled during 1941 and completed in February 1942 with an initial production of 182 bbl. of 47.4° gr. oil. This well was drilled to a total depth of 9850 ft. where it encountered the basement. Tests made around this depth yielded 136½ bbl. per day of light oil from basal Cretaceous Mercedes sandy lime.

Socuavo Well No. 2, about 4 miles northwest of Socuavo No. 1, was completed during the year. It was completed as a producer at a final depth of 4961 ft., with an initial production of 197 bbl. of 31.5° gr. oil.

Socuavo Well No. 3 was spudded in during October, and at the year's end had reached a depth of 4845 feet.

Socuavo Well No. 4 was being prepared for drilling at the end of the year.

Tres Bocas No. 2-A was drilled to a total depth of 9228 ft. and was completed around the middle of the year, with an initial production of 1000 bbl. of 57° gr. oil from the Cretaceous. Subsequent tests showed the following: ¼-in. choke, 660 bbl. per day; ⅜-in. choke, 900 bbl. per day; ⅝-in. choke, 1700 bbl. per day. Oil from this well is 50° A.P.I. or higher, and is practically a distillate.

On Tres Bocas No. 3 drilling commenced in May 1942. It was carried to a total depth of 5,070 ft. and plugged back to 4530 ft. This is an edge well in the Tertiary and produces 27° gr. asphalt-base oil from the Barco formation.

Sardinata Norte No. 1 was abandoned as a dry hole on Feb. 13, 1942. This test drilled to a total depth of 5005 feet.

* Colombian Exploration Gives Promise of Important New Production. *World Petroleum* (Sept. 1942) **13**, 45.
Colombia's Casabe Field Showing Major Calibre. *Oil and Gas Jnl.*, (Dec. 31, 1942) **41**, 60.

Compania de Petroleos del Carare, S.A.

This company's MacCarthy No. 1, on the east bank of the Magdalena, about 12 km. north of Puerto Wilches, was abandoned as a dry hole on June 12, 1942. The concession on which this well is located was acquired by transfer from Wm. A. MacCarthy in May 1940. The well was drilled to a total depth of 5438 ft., where it encountered the Cretaceous. A test of the section between 4873 and 4882 ft. yielded some tarry oil. A formation test at 4182 to 4225 ft. resulted in nothing more than a scum of oil after the tester had been open for 30 minutes.

Compania de Petroleos del Valle del Magdalena

Cantagallo No. 2, on this company's Cantagallo or Cimitarra concession, on the west side of the Magdalena River in the Department of Bolivar, had drilled to a depth of 5062 ft. at the end of 1942.

Compania Colombiana de Petroleo Occidental, S. A.

This company's Villamizar concession is on the west bank of the Magdalena River, in the municipality of Simiti, Department of Bolivar, and was acquired by transfer from Sr. L. A. Villamizar. During 1942 the Richmond Petroleum Co. of Colombia drilled Culimba No. 2 for Cia. Colombiana de Petroleo Occidental, S.A., on the Villamizar concession to 4273 ft. and abandoned it as a dry hole, having penetrated Quaternary, Tertiary, and Cretaceous formation. (The well is 2.45 km., S. 18½°W. of lat. 7°30′ N., long. 0°10′ E. of Bogota.)

Compania Colombiana de Petroleo Sierra Nevada, S.A.

Also during 1942, the Richmond Petroleum Co. of Colombia drilled Braval No. 1 and No. 2 for Cia. Colombiana de Petroleo Sierra Nevada, S.A., on the Camacho Roldan concession. Both wells were abandoned as dry holes at 2812 ft. and 3544 ft., respectively, having penetrated Quaternary, Tertiary, and Cretaceous formation. (Braval No. 1 is 11.2 km. N. 33°W. of lat. 7°30′ N., long. 0°10′ E. of Bogota. Braval No. 2 is 7.12 km. N. 30°W. of lat. 7°30′ N., long. 0°10′ E. of Bogota.) Other drilling was confined to structure holes of shallow depth.

Compania de Petroleo Shell de Colombia

This company's El Doce concession, transferred from Cia. Anglo-Colombiana de Petroleo in 1941, is in the lower Magdalena Valley east of the Magdalena River in the Department of Magdalena. El Doce No. 1 commenced drilling on March 13, 1942, and was abandoned in November at a total depth of 10,046(?) ft., where the basement was encountered. All tests were negative. El Doce No. 1 is 8 km. NNW. of Arjona and 12 km. NNE. of the town of El Doce.

Another test, El Brillante No. 1, was spudded in on this concession during the latter part of November.

Compania de Petroleo La Estrella de Colombia

The El Dificil concession of this company is north of the El Doce concession of the Cia. de Petroleo Shell, in the Department of Magdalena. The first test well, El Dificil No. 1, was started around the middle of the year and was drilling at the end of the year. A gas show was reported at about 3300 feet.

Compania de Petroleos La Perla de Colombia

The Palagua No. 1 test, commenced by this company on its Obregon Arjona concession late in 1941, was abandoned as a dry hole in January 1942. This hole drilled to a total depth of 3536 ft. Basement was encountered at 3483 feet.

Compania Colombiana de Petroleos
El Condor

All present indications point to the development of a new Colombian field of sizable proportions in the area covered by this company's Yondo concession. A moderate development program was carried out on this concession during the year, with the most encouraging results. Seven wells were drilled and all were completed as producers. The following summary lists the production ratings of the wells completed during 1942:

Casabe Well	Bbl. per Day	Production Method	Gravity, Deg. A.P.I.	
No. 2	150	Pumping	22.1	H.C.T.
No. 3	608	Flowing	22.0	H.C.T.
No. 4	208	Flowing	20.3	L.C.T.
No. 5	1,230	Flowing	21.0	
No. 6	1,000	Flowing		
No. 7	1,500?	Flowing		
No. 8	800	Flowing		

The production from these wells is from the Colorado formation (zone A).

Casabe No. 9 was prepared to spud in at the end of 1942.

Tropical Oil Company

De Mares Concession.—Drilling operations on Tropical's De Mares concession during the year consisted of the completion of six C-zone wells in La Cira field; four of these were producers and two were dry holes. Most of the wells on the property were shut in during the last half of the year because of restricted outlet. Pipeline runs were reduced considerably during the year and the production from the Infantas and La Cira fields totaled only 9,453,995 bbl., including 126,607 bbl. of petroleum condensate added to crude.

Cimitarra (Gutierrez) Concession.—Wildcat operations on Tropical's Cimitarra (Gutierrez) concession were discontinued during the year after the completion and abandonment of two test wells. Cimitarra No. 1 drilled to a total depth of 9502 ft., where it was abandoned in the Lower Cretaceous. Cimitarra No. 2 commenced drilling in April, reached the Cretaceous and was abandoned at a total depth of 4171 ft. This well encountered showings of tarry oil but failed to yield any oil when tested. Application to surrender the concession was filed in May.

1943

The production of crude oil in Colombia during 1943 amounted to 13,418,317 bbl. Although this total is only a little better than half of the total for 1941, it is 26 per cent more than the corresponding figure for 1942. The improvement was due to the lessened risk of losing tankers from the attacks of submarines and the greater volume of exports that naturally followed after last June, when pipe-line runs to seaboard were first stepped up.

Up to the year's end all the commercial production of Colombia came either from Tropical Oil Company's De Mares concession or from Colombian Petroleum Company's Barco concession. The proportion contributed by each company, in barrels, over each of the last three years may be noted from the following table:

Company	1941	1942	1943
Tropical Oil Co.	20,785,309	9,453,995	11,644,438
Colombian Petr. Co.	3,942,525	1,163,013	1,773,879
Total	24,727,834	10,617,008	13,418,317

This table includes petroleum condensate in Tropical's production (162,873 bbl. for 1943), but it does not show any production that was recovered by Condor as a result of testing operations conducted in the early stage of its development of the new Casabe field. Likewise excluded is any oil recovered from testing operations by Cia. La Estrella on its Dificil No. 1 discovery well, and by Cia. del Valle del Magdalena on its Cantagello No. 2 discovery well.

Exploration in 1943

Exploratory drilling for the year was on a reduced scale in comparison with the previous year, largely because of the shortage of equipment in the country resulting from maritime shipping restrictions on freight to South American points. None the less, a fair degree of success was met with. Whereas the 13 wildcats completed in 1942 had resulted in four producers, all of which were on the Barco concession, in 1943 the 10 wildcats completed included three discovery wells on the Barco tract and two other very widely separated discovery wells. One of these discovery wells, known as Dificil No. 1, is 90 miles from tidewater in the Lower Magdalena Valley and the other, called Cantagallo No. 2, is close to the Magdalena River and only some 19 miles north of Condor's Casabe field, which in turn is just opposite Tropical's De Mares concession, as may be seen from the accompanying map. On the other hand, the three discoveries on the Barco concession are separated by only 2 miles or so from one another, and all lie on or near the Socuavo portion of the Tibu structure.

The three Socuavo wells had depths of 5245, 5313 and 5675 ft., respectively, and initial production rates of 197, 921 and 389 bbl. per day. The Cantagallo No. 2 well reached a depth of 6170 ft. and tested 286 bbl. per day. The Dificil No. 1 well had a total depth of 5996 ft. and an initial production rated at 54 bbl. per day.

Of the five discoveries, the Dificil No. 1 well has stirred up most exploratory interest because its crude has a gravity of 45° A.P.I., and the well is not only close to tidewater but is in a region that is considerably removed from previously proven fields and not yet completely blanketed by applications for oil concessions.

At the year's end six wildcats were either drilling or testing and at least four others had been planned for 1944. The details are given in Table 3.

Two factors of interest that may be mentioned in connection with exploratory activity are: (1) the possible entrance of another major company into Colombia, and (2) the possible revision of the current oil law governing the granting of oil concessions. The major company mentioned as a possible entrant is Gulf, which is understood to be contemplating the acquisition of some or all of seven concessions said to be controlled by the Colombian company known as Regalias Petroliferas. As far as the possibility of a change in the oil law is concerned, it can only be said now that the proposed new law had considerable discussion in the House during 1943 but definite conclusions on the final disposition of the proposed law have not yet been reached.

The area under contract or application as of Dec. 31, 1943, excluding some 676,000 ha. that were renounced, was more than 3 million hectares. A year earlier, the corresponding figures, excluding some 553,000 ha. renounced, were 2.4 million hectares. In short, this means that the net increase in lands applied for over lands surrendered in 1943 was some 600,000 ha. (about 1,500,000 acres). This net gain of 600,000 ha. represents a 25 per cent increase in land holdings in one year, and is another indication of the continued activity being shown in this phase of exploratory work.

Development* Drilling in 1943

Development operations in Colombia as a whole continued to be on a relatively small scale. No development drilling was done by Colombian Petroleum on the Barco concession; Tropical completed only three wells on its De Mares concession; and Condor on its Yondo tract completed six new Casabe wells, of which five were producers.

* See also Dr. E. Ospina-Racines' interesting summary: Wildcat Operations Yield Encouraging Results in Colombia. *World Petroleum* (Sept. 1943) 14, 36.

Activities of Operating Companies

The following details of the activities carried on by each of the operating companies may be mentioned:

Colombian Petroleum Company

Colombian Petroleum Co. produced 1,773,829 bbl. of crude from its Barco concession—an average of 4860 bbl. per day as compared with 3186 in 1942 and 10,801 in 1941. It did no drilling during the year on its proven areas but concentrated its drilling on exploring the possible extension of the productive area on to the Socuavo portion of the Tibu structure, which it had proved productive in 1942 by the discovery wells Socuavo Nos. 1 and 2. Three widely spaced wells known as Socuavo No. 3, No. 4 and No. 5 were completed as producers. The wells recently completed or now on the drilling program include:

Socuavo No. 3, on the west flank of the structure, 2½ miles south of Socuavo No. 2 and 2 miles northwest of Socuavo

Table 1.—*Oil and Gas Production in Colombia, South America*

Line Number	Field, *Department*[a]	Year of Discovery	Total Oil Production, Bbl.: To End of Year Indicated	Total Oil Production, Bbl.: During Year Indicated	Number of Oil and/or Gas Wells: Completed to End of Year Indicated	During Year Indicated: Completed	During Year Indicated: Abandoned	End of Year Indicated: Temporarily Shut Down	End of Year Indicated: Producing Oil[e]	End of Year Indicated: Producing Gas[e]
	1943									
1	Casabe (Yondo), *Antioquia*	1941	Negligible	(no outlet)	13	5			13	
2	Cimitarra (Cantagallo), *Bolivar*	1943	Negligible	(no outlet)[1]	1	1	0	0	1	
3	El Dificil, *Magdalena*	1943	Negligible	(no outlet)	1	1	0	0	1	
4	Infantas, *Santander*	1918	136,480,687	2,785,993	470	0	0		441	0
5	La Cira, *Santander*	1926	176,906,779	8,858,445	700	3	0		678	0
6	Las Monas, *Santander*	1926				0				
7	Carbonera, *Santander del Norte*	1939			3	0	0			
8	Petrolea (N. Dome), *Santander del Norte*	1933	12,710,744	1,741,636	130	0	0			
9	Petrolea (S. Dome), *Santander del Norte*	1939			1	0	0			
10	Rio de Oro, *Santander del Norte*	1937	66,411	1,703	9	0	0			
11	Socuavo, *Santander del Norte*	1942	85,825	30,540	5	3	0		5	0
12	Tres Bocas, *Santander del Norte*	1940			4	0	0		3	0
	1944									
1	Casabe (Yondo), *Antioquia*	1941	Negligible	(no outlet)	25	12	1		25	
2	Cantagallo, *Bolivar*	1943	53,399[3]	40,399[3]	4	1	2		2	0
3	El Dificil, *Magdalena*	1943	Negligible	(no outlet)	3	2	0		2	
4	Infantas, *Santander*	1918	139,937,638	3,456,951	471	1			442	
5	La Cira, *Santander*	1926	191,532,054	14,625,275	703	3			681	
6	Las Monas, *Santander*	1926			0					
7	Carbonera, *Santander del Norte*	1939			3	0	0	3		
8	Petrolea (N. Dome), *Santander del Norte*	1933	16,606,386	3,895,642	130	0	0	2	77	20
9	Petrolea (S. Dome), *Santander del Norte*	1939			1	0	0		1	
10	Rio de Oro, *Santander del Norte*	1937	66,990	579	9	0	0	9		
11	Socuavo, *Santander del Norte*	1942	769,252	683,427	12	7	0	1	11	
12	Tres Bocas, *Santander del Norte*	1940			5	1	0	2	2	

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[1] Total produced in this field from testing operations in 1943 10,742.
[3] Produced for field use; no outlet (Cantagallo field).

No. 1, was completed at a depth of 5245 ft. in the top of the Rio de Oro formation (Cretaceous), with an initial production of 197 bbl. per day on ⅜-in. choke.

Socuavo No. 4, on the east flank of the structure, 2¾ miles south-southeast of Socuavo No. 1, was completed at 5313 ft. at the base of the Catatumbo formation (Eocene), with an initial production of 921 bbl. per day on ⅜-in. choke.

Socuavo No. 5, on the east flank of the structure, about 2 miles east of Socuavo No. 1, was completed at 5675 ft. in the Rio de Oro formation with an initial production of 389 bbl. per day on ⅜-in. choke.

Socuavo No. 6 is a new location about 1½ miles northeast of Socuavo No. 2.

Socuavo No. 7 is about 2100 ft. S. 40° E. of Socuavo No. 4 and was drilling at the year's end in the Los Cuervos formation (Eocene) at a depth of 4290 feet.

Tres Bocas No. 4 completed preparations for spudding in.

Cia. de Petroleo La Estrella de Colombia

Probably the most notable discovery of the year was made by Cia. de Petroleo

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation	Character of Oil: Gravity A.P.I. at 60°F. Weighted Average	Producing Formation: Name	Age[j]	Character[k]	Porosity[l]	Depth, Avg. Ft.: Top Prod. Zone	Depth, Avg. Ft.: Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[o]	Deepest Zone Tested to End of Year Indicated: Name	Depth of Hole, Ft.
1943												
1		21.0	Colorado	Olig	S						Cretaceous	8,202
2		20.1	Lisama	Eoc	S	27	5,696				Umir (Cretaceous)	6,088
3		45.0		Olig	L						(basement)	5,996
4	39[2]	23.8	A, B, C, zones	Olig Eoc	S	15-22	400-2,200	1,000-2,600	50-200	AF	Cretaceous	4,048
5			A, B, C, zones	Olig Eoc	S	15-25	400-3,950	600-4,294	50-175	AF	Cretaceous	8,051
6			Chuspas	Olig	S					AF	Cretaceous	
7		21.5	Los Cuervos Barco	Eoc	S		800-1,720			AF	Barco	2,722
8		39.1-47.1	La Luna, Cogollo Uribante	Cre	LS, S		130-1,180			AF	Uribante	3,007
9		37.7	Cogollo	Cre	LS		1,350			AF	Uribante	2,640
10		30.0-40.0	Catatumbo and Rio de Oro	Eoc Cre	S		1,100-1,400			AF	Cogollo	6,717
11		49.7	Barco, Catatumbo and Uribante	Eoc	S		4,700-8,340			AF	Uribante	9,850
12		30.8		Cre	LS		4,200-8,867			AF	Mercedes	9,228
1944												
1		21.0	Colorado	Olig	S						Cretaceous	8,202
2		20.1	Lisama	Eoc	S		5,800			AF	Umir (Cretaceous)	7,054
3		45.0		Olig	L							6,475
4	25[2]		A, B, C, zones	Olig Eoc	S	15-22	400-2,200	1,000-2,600	50-200	AF	Cretaceous	4,048
5	17[2]	24.61	A, B, C, zones	Olig Eoc	S	15-25	400-3,950	600-4,294	50-175	AF	Cretaceous	8,051
6		21.5	Chuspas	Olig	S					AF	Cretaceous	
7			Los Cuervos, Barco	Eoc	S		800-1,720			AF	Barco	2,722
8		39.1-47.1	LaLuna, Cogollo, Uribante	Cre	LS, S		130-1,180			AF	Uribante	3,007
9		37.7	Cogollo	Cre	LS		1,350			AF	Uribante	2,640
10		30.0-40.0	Catatumbo and Rio de Oro	Eoc	S		1,100-1,400			AF	Cogollo	6,717
11		49.7	Barco, Catatumbo, and Uribante	Eoc	S		4,700-8,340			AF	Uribante	9,850
12		30.8		Cre	LS		4,200-8,867			AF	Mercedes	9,228

[2] Number of repressuring key wells.

TABLE 2.—*Summary of Drilling Operations in Colombia, South America*

	Department	Location: Survey	Location: Lat.	Location: Long.	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day: Oil, U.S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.: Casing	Pressure, Lb. per Sq. In.: Tubing	Remarks
	Important Wildcats Drilled in 1943													
1	Magdalena	El Dificil No. 1	N. 1102028 m. Equator	W. 2363 m. of Bogota	5,996		Oligocene	Cia. de Petroleo La Estrella de Colombia	54	0.7	1/8			Discovery well
2	Antioquia	Cano Negro No. 1	N. 786360 m. Equator	E. 10280 m. of Bogota	5,434			Cia. Colombiana de Petroleos El Condor						Dry hole, abandoned
3	Bolivar	Cantagallo No. 2	7°21′28″ N. Equator	0°9′14″ E. of Bogota	6,170	Quaternary	Cretaceous	Cia. de Petroleos del Valle del Magdalena	286		3/8	320	100	Discovery well
4	Bolivar	Braval No. 3	7°41′ N.	Greenwich 73°58′30″ W.	923	Quaternary	Cretaceous	Cia. Colombiana de Petroleo Sierra Nevada	0					Dry hole, abandoned
5	Bolivar	Braval No. 4	7°44′ N.	73°57′15″ W.	881	Quaternary	Cretaceous	Cia. Colombiana de Petroleo Sierra Nevada	0					Dry hole, abandoned
6	Bolivar	Braval No. 5	7°45′30″ N.	73°56′ W.	812	Quaternary	Cretaceous	Cia. Colombiana de Petroleo Sierra Nevada	0					Dry hole, abandoned
7	Santander del Norte	Socuavo No. 3	Barco	Conc.	5,245	Leon shale (Oligocene)	Catatumbo (Eocene)	Colombian Petroleum Co.	197		3/8	750	80	Producer
8	Santander del Norte	Socuavo No. 4	Barco	Conc.	5,313	Leon shale (Oligocene)	Catatumbo (Eocene)	Colombian Petroleum Co.	921		3/8	610	590	Producer
9	Santander del Norte	Socuavo No. 5	Barco	Conc.	5,675	Leon shale (Oligocene)	Catatumbo (Eocene)	Colombian Petroleum Co.	389		3/8	15	220	Producer
	Important Wildcats Drilled in 1944													
1	Meta	San Martin No. 1	3°46′37″ N. of Eq.	0°23′25.2″ E. of Bog.	3,079			Compania Petroleo Shell de Colombia						Fresh-water well
2	Magdalena	El Brillante No. 1	9°43′20″ N. of Eq.	0°09′06″ E. of Bog.	10,250			Compania Petroleo Shell de Colombia						Dry hole, abandoned
3	Magdalena	El Doce No. 2	9°29′20″ N. of Eq.	0°02′06″ W. of Bog.	4,003			Compania Petroleo Shell de Colombia						Dry hole, abandoned
4	Magdalena	San Angel No. 1	10°02′25″ N. of Eq.	0°05′19″ W. of Bog.	9,130			Cia. de Petroleo La Perla de Colombia		0.684				Gas well
5	Magdalena	San Angel No. 2	10°06′15″ N. of Eq.	0°05′29″ E. of Bog.	4,931			Cia. de Petroleo La Perla de Colombia						Dry hole, closed in
6	Magdalena	El Retiro No. 1	9°30′35″ N. of Eq.	0°03′01″ E. of Bog.	5,802	Miocene	Oligocene	Richmond Petroleum Company of Colombia						Dry hole, abandoned
7	Magdalena	El Retiro No. 2	9°99′25″ N. of Eq.	0°02′01″ E. of Bog.	1,525	Miocene	Oligocene	Richmond Petroleum Company of Colombia						Dry hole, abandoned

	1943: In Proven Fields	1943: Wildcats	1944: In Proven Fields	1944: Wildcats
Number of wells drilling Dec. 31	3	6	7	4
Number of oil wells completed during year	8	5	24	0
Number of gas wells completed during year			0	1
Number of dry holes completed during year	1	5	5	6

La Estrella de Colombia when it completed successfully its Dificil No. 1 well as a producer of high-gravity crude in a strategic area. This well is on the Dificil tract about 90 miles from the Caribbean coast and 50 miles from the Andian National Pipeline. It started drilling about the middle of 1942 and reached a total depth of about 5996 ft., at which point a basement of granitic material was encountered. On its completion about the middle of May 1943, it was reported to have flowed at the rate of 54 bbl. per day of 45° A.P.I. drilling at a depth of approximately 9000 feet.

Cia. de Petroleo Shell de Colombia

Shell de Colombia spudded in its Brillante No. 1 on its El Doce concession about 9 miles north of its previous deep test known as Doce No. 1, which had been abandoned in 1942 after reaching a total depth of 10,046 ft. The new well was started Dec. 1942, and as of Dec. 31, 1943 had reached a depth of approximately 10,250 ft. and was testing.

TABLE 3.—*Wildcats Still Incomplete at Dec.* 31, 1943 *and New Ones Planned*

Well	Depth, Ft., and Status	Company	Concession	Region
		INCOMPLETE		
Socuavo No. 7	4,290 Drilling	Colombian Petr. Co.	Barco	NE. Col.
El Retiro No. 1	4,327 Drilling	Richmond Petr. Co.	Granger	Lower Magdalena
San Angel No. 1	9,000 Drilling	Cia. de Petr. La Perla de Col.	San Angel	Lower Magdalena
El Brillante No. 1	10,250 Testing	Cia. de Petr. Shell de Colombia	El Doce	Lower Magdalena
El Dificil No. 2	6,150 Testing	Cia. de Petr. La Estrella de Colombia	El Dificil	Lower Magdalena
Cantagallo No. 4	4,700 Drilling	Cia. de Petr. del Valle del Magdalena	Cantagallo	Middle Magdalena
		PLANNED FOR 1944		
Tres Bocas No. 4		Colombian Petr. Co.	Barco	NE. Col.
Socuavo No. 6		Colombian Petr. Co.	Barco	NE. Col.
Floresanto No. 1		Sindicato de Inversiones, S.A.	Pena	Sinu Area
San Martin No. 1		Cia. de Petr. Shell de Colombia	San Martin	Eastern Colombia

crude through an ⅛-in. choke, with a gas volume of 700,000 cu. ft. of wet gas. The Cretaceous was not encountered in this well and production is understood to be coming from a porous coral-reef limestone of Upper Oligocene age.

In July of 1943 Dificil No. 2 was spudded in at a location approximately one mile northwest of Dificil No. 1. At the year's end, No. 2 had reached a depth of about 6150 ft. and was testing.

Cia. de Petroleo La Perla de Colombia

The San Angel No. 1 well of Cia. de Petroleo La Perla de Colombia is on the concession of the same name about 12 miles north of Dificil No. 1, and was spudded in late in May 1943. At the year's end it was

At the year's end the company had started road building and the erection of a derrick on its San Martin concession of 99,975 ha. in eastern Colombia. This test, which is to be called San Martin No. 1, will be about 12 miles south of the town of Villavicencio, in the foothills, and will be the first ever to be attempted in this region.

Cia. Colombia de Petroleo El Condor

The Condor spudded in a wildcat known as Cano Negro No. 1 in the northwestern part of its Yondo tract and about 7 miles west of its Casabe field. This test was started on Sept. 27, 1943 and completed Nov. 23, 1943, as a dry hole with a total depth of 5434 feet.

In addition, six new development wells, Casabe Nos. 9 to 14 inclusive, were completed on the Yondo tract. With the exception of Casabe No. 10, which was a dry hole about ½ mile northwest of the nearest producer, all these wells were producers. Two of the five were reported to have initial ratings of 700 and 797 bbl. per day. This field is now unofficially reported to have a potential in the neighborhood of 4000 bbl. per day of 20° to 22° crude, and present indications are that this development may result in a field of some importance.

Cia. de Petroleo del Valle del Magdalena

The first well to be drilled on the Cimitarra or Cantagallo concession of the Cia. de Petroleo del Valle del Magdalena, which is opposite Pto. Wilches on the Magdalena River and just north of the Yondo tract, was Cimitarra (Cantagallo) No. 1, which was completed at a total depth of 1494 ft. in 1941 and shut in as a gasser.

Cantagallo No. 2 is about 2½ miles south of Cantagallo No. 1 and was started on Aug. 31, 1942. It reached a depth of 6170 ft. in March 1943 and until Sept. 29 it was testing. On that date it was brought in with an initial production of 286 bbl. per day of 19° to 20° A.P.I. crude, through a ⅜-in. choke, from the Eocene at an approximate depth of 5696 ft. The top of the Cretaceous is at about 6088 feet.

Cantagallo No. 3 was spudded in about ¼ mile west of No. 2 in late August, and drilled to the top of the basement at a total depth of 4017 feet.

Cantagallo No. 4 is 780 meters south and 231 meters west of No. 2. Drilling began on Nov. 1. As of Dec. 31, 1943, it had reached a depth of about 4700 feet.

Richmond Petroleum Company of Colombia

The Richmond started drilling on its Doce concession just south of Shell's Doce concession, where Brillante No. 1 is now testing, by spudding in its El Retiro No. 1 at a site about 54 miles north of El Banco and 7 miles southeast of Shell's Doce well. Retiro No. 1 started May 1, 1943, in beds of Miocene age, and at the end of the year was in Lower Miocene and at a total depth of 4327 feet.

Cia. Colombia de Petroleo Sierra Nevada

The Richmond, in addition to its operations on its Doce tract, completed three holes for the Sierra Nevada company in 1943, on the latter company's Camacho Roldan tract. These holes, known as Braval Nos. 3, 4 and 5, were shallow core-hole tests drilled to total depths of 923, 881 and 812 ft., respectively All three were abandoned as dry holes after testing the Cretaceous without finding any shows.

Sindicato de Inversiones S.A.

Toward the end of the year, the Sindicato de Inversiones S.A., a Socony-Vacuum subsidiary, was preparing to start drilling early in 1944 on a test well in the Sinu district, northern coastal area, where it has a concession acquired from Sr. Roberto Pena on Jan. 31, 1942. This test well will be known as Floresanto No. 1.

Tropical Oil Company

Tropical completed three C-zone development wells on the La Cira structure in the De Mares concession. One of these wells had an initial production of 665 bbl. per day and another was rated at 150 bbl. per day. No wells were abandoned during the year. The Infantas structure produced 2,785,993 bbl. of oil, including 88,878 bbl. of condensate, and La Cira 8,858,445 bbl., including 73,995 bbl. of condensate.

The Gutierrez (Cimitarra, No. 52 on map) concession of this company, which lies between the Condor's Yondo and Valle's Cantagallo tracts, was surrendered during the year. It will be recalled that

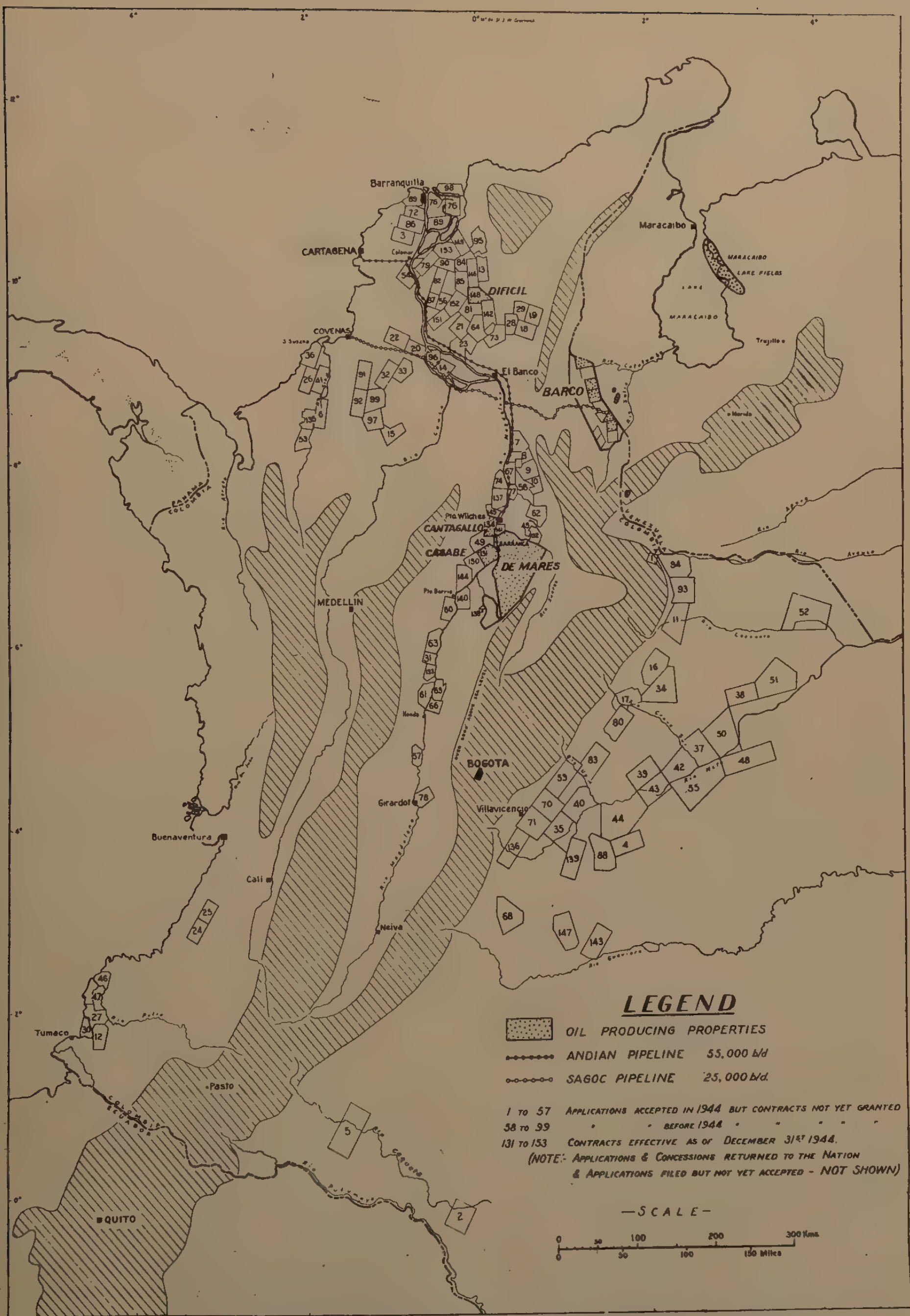

FIG. 1.—LOCATIONS OF PRODUCING PROPERTIES AND PIPE LINES IN COLOMBIA.

two dry holes were completed on this concession in 1942.

1944

The oil industry in Colombia, so favorably located in the Caribbean area, continued to intensify its effort to increase production and to develop new oil. The number and area of concession applications actually filed again made a new record. Other exploratory activities were also at a high level during the year, despite the limitations imposed on them by the restricted supply of drilling and automotive equipment.

Production

Owing to the return of a nearly normal tanker situation, the production of crude oil during 1944 made a very sharp recovery from 1943's abnormally low figure. The total production for the year 1944 was nearly 23 million barrels—about 90 per cent of the 1941 total. It is also approximately twice as much as the annual production for each of the years 1942 and 1943, which produced only some 10 and 13 million barrels, respectively.

The country's total production was once more provided—probably for the final year—by only two companies; namely, Tropical Oil and Colombian Petroleum. Tropical's De Mares concession supplied more than 18 million barrels, or 80 per cent of the total, and the remainder of the production came from the Colombian's Barco tract. The locations of these two tracts and other areas of interest are shown on the accompanying map (Fig. 1). The following table gives the crude production, in barrels, of Colombia for each of the past four years, and shows that the Barco tract has recently been contributing an increasing proportion of the country's total supply:

Company	1941	1942	1943	1944
Tropical Oil Co.	20,785,309	9,453,995	11,644,438	18,082,226
Colombian Petr. Co.	3,942,525	1,163,013	1,773,879	4,579,648
Total[a]	24,727,834	10,617,008	13,418,317	22,661,874

[a] The cumulative total to Dec. 31, 1944 is 348,912,320 (see Table 1).

It should be noted that this table excludes the crude oil recovered as a result of testing operations of Shell interests conducted by its Cia. Condor in the Casabe field development work, and by its Cia. Estrella in the Dificil field. Likewise omitted is the production obtained by the Socony interests from testing done by the Cia. del Valle in the Cantagallo field, as well as 40,399 bbl. produced there for field use.

It is expected that during the course of 1945 the Colombian production will be increased by crude oil from the Casabe field as soon as a pipe-line connection has been made between the field and the Andian pipe line. At the year end Casabe had completed 25 producing wells with an aggregate initial production estimated at about 16,000 bbl. per day, and was pursuing a steady program of development.

Exploration in 1944

Exploratory drilling in Colombia as a whole continued on a scale similar to that experienced in 1943. Seven wildcat wells (Table 2) were completed, all of which gave negative results. Six of the tests were in the Magdalena Valley and one in eastern Colombia; the latter, incidentally, being of more than usual interest because it is the first test well attempted in this region.

Although wildcatting did not discover any new fields in areas lying outside of

concessions on which there were already discovery wells, new production of importance was opened up by eight additional wells in the Barco concession in its Tibu area, and was adding 2800 bbl. per day of 32° oil to Barco's export volume in the last quarter of the year. In addition, a second producer was completed by Shell on the Dificil tract in the lower Magdalena Valley, and Socony added a producer at Cantagallo in the middle Valley opposite Puerto Wilches. Also, stepout operations in Shell's Casabe field opposite Barranca were continued with good results.

Leasing and Legislation in 1944

Not only did surface exploration along geological and geophysical lines continue to be very actively prosecuted by major companies, but lease applications actually filed during the year made a new record, both in number and in the total area covered. A good indication of the recent trend in leasing for the last 3 years is given in Table 4, which shows that applications filed in 1944 exceeded in number those filed in the 11 years 1931–1941 and covered double the area.

Table 4.—*Summary of National Lands Held in Colombia*

Year	Applications Filed during Year		Applications and Contracts Retained at End of Year	
	Number	Hectares	Number	Hectares
1931–41	116	4,370,918	59	2,556,504
1942	14	677,226	66	2,942,819
1943	77	4,583,077	131	7,299,469
1944	122	8,747,459	241	15,435,191

The industry had anticipated a modification of the petroleum law and several changes of the draft of a new law did receive considerable discussion in the Congress for some weeks, but actually no new petroleum legislation of importance was enacted during the year.

Activities of Operating Companies

The following are items of interest with respect to the activities of the operating companies in Colombia.

Tropical Oil Company

Four wells were completed by Tropical on its De Mares concession during the year. The year's production was 18,082,226 bbl., of which 371,332 bbl. represented petroleum condensate added to pipe-line crude.

The Supreme Court rendered its decision on the expiry date of the De Mares concession, and this decision upheld the company's contention that the date was Aug. 25, 1951, and not June 14, 1946.

Colombian Petroleum Company

Production from the Barco concession was increased gradually throughout the year. The Petrolea field maintained a fairly constant rate of about 11,000 bbl. per day of 46° A.P.I. oil, and in March the Tibu field (formerly called Socuavo-Tres Bocas) began production for export of 32° A.P.I. oil, which is being marketed separately from the high-gravity Petrolea crude. The first Tibu oil reached Covenas, the pipe-line terminal, in the latter part of May, and the first shipment was made in the middle of August. Tibu production averaged 1300 bbl. per day in the second quarter of the year, 2600 bbl. per day in the third quarter, and more than 2800 bbl. per day in the fourth quarter.

Production for 1944 was 4,579,648 bbl. as compared with 1,773,879 bbl. in 1943, when production was restricted by lack of tankers during the first seven months. Cumulative production of the Barco concession was 17,442,628 bbl. at the end of 1944.

No drilling was done in the Petrolea field in 1944, but drilling with two rigs was continuous in the Tibu field. During the year, 46,600 ft. of hole was drilled.

No deep Cretaceous tests were drilled in 1944, but eight wells were completed in the Tertiary at depths of 4000 to 5000 ft., as follows: Socuavo No. 7, 0.4 miles southeast of Socuavo No. 4; Socuavo No. 8, 0.4 miles northwest of Socuavo No. 4; Tres Bocas No. 5, 1.4 miles east of Tres Bocas No. 2-A; Socuavo No. 9, 0.8 miles southeast of Socuavo No. 4; Socuavo No. 10, 1.2 miles southeast of Socuavo No. 4; Socuavo No. 11, 0.4 miles northwest of Socuavo No. 8; Socuavo No. 12, 1.6 miles northeast of Socuavo No. 8; and Socuavo No. 13, 0.4 miles northeast of Socuavo No. 11.

Wells drilling Dec. 31, 1944, were Socuavo No. 14 (Tibu L-25), 0.8 miles northeast of Socuavo No. 4, and Socuavo No. 15 (Tibu L-23), 0.8 miles northeast of Socuavo No. 9.

The eight wells completed from Jan. 1 to Oct. 31, 1944 averaged initially more than 250 bbl. per day of 32° A.P.I. oil on ¼-in. choke.

It is anticipated that a Cretaceous test to about 10,000 ft. will soon be started at Tres Bocas No. 4, 2.3 miles south-southeast of Tres Bocas No. 2-A. This location was partly rigged up a year ago but could not be drilled because of lack of certain materials.

Compania Petroleo Shell de Colombia

This company's El Brillante No. 1 well, after reaching a total depth of 10,250 ft. toward the end of 1943, was abandoned as a dry hole in February 1944. Testing of this well yielded only salt water and traces of of gas. Drilling at this location started in January 1942. E. Brillante No. 2, some 6 km. north of No. 1, commenced drilling in October 1944 and at the year's end was drilling and coring at 4526 ft. El Doce No. 2 spudded in on April 11, 1944, and was abandoned as a dry hole in July, at a total depth of 4003 ft. These tests were on Shell's El Doce concession, in the Department of Magdalena.

Drilling operations on Shell's San Martin concession in the Intendencia del Meta, eastern Colombia, commenced the early part of 1944. Drilling progress on this well, San Martin No. 1, was greatly hampered by strong flows of fresh water, and the well was abandoned at the end of 1944, at 3079 ft. Preparations for the commencing of San Martin No. 2 were under way at the end of the year.

Compania de Petroleo la Perla de Colombia (*Shell*)

This company's San Angel No. 1 was completed as a gas well in January 1944, with an estimated production of 684,000 cu. ft. of gas and 560 bbl. of salt water per day. Total depth of this well is 9130 ft. San Angel No. 2 commenced drilling in July 1944; it reached a depth of 4931 ft., where it encountered salt water and was mudded off and closed in. This well is 7 km. north of No. 1. San Angel No. 3 spudded in on Nov. 14, 1944, and at the year's end was drilling ahead at 3087 ft. The San Angel tests are on this company's concession of the same name in the Department of Magdalena.

Compania Petroleo la Estrella de Colombia (Shell)

Drilling operations on this company's Dificil tract in the Department of Magdalena were accelerated during the year following the discovery of high-gravity crude in Dificil No. 1, which was completed in 1943

El Dificil No. 2, approximately 2 km. northwest of the discovery well, was drilled to a total depth of 6475 ft. Testing of this well yielded salt water with some traces of oil. This well was closed in on March 20, 1944.

El Dificil No. 3 is 1 km. north of the discovery well No. 1. Drilling operations on this well were completed in August 1944, having penetrated to a total depth of 5850 ft. Testing operations proceeded

throughout the remainder of the year. Dificil No. 3 is rated with an initial production of from 600 to 1000 bbl. of 42.3° A.P.I. crude per day.

El Dificil No. 4 commenced drilling on Nov. 8, 1944, and at the year's end had reached a depth of 4213 ft. It is about ½ km. southeast of the discovery well.

Derrick on El Dificil No. 5 was completed at the year's end. This well is about ½ km. east of No. 3.

Compania Colombiana de Petroleo el Condor (Shell)

Development drilling on the Yondo concession of Cia. Colombiana de Petroleo el Condor (Shell) continued throughout the year, resulting in the successful completion of 12 additional producers in the Casabe field (Casabe wells Nos. 15–26, inclusive). Initial production ratings of these new wells range from 100 to 1000 bbl. of 20° to 24° A.P.I. crude per day. Plans for the transporting of Casabe crude to tidewater are well advanced, and it is expected that this oil will move through Andian National's pipe line in 1945.

Cia. de Petroleo del Valle del Magdalena (Socony-Vacuum)

Socony-Vacuum operations were continued by its operating company, Cia. de Petroleos del Valle del Magdalena. On its Cantagallo concession (formerly called Cimitarra) three wells were completed during the year, one as a producer and two as dry holes, and a fourth well was spudded in. Cantagallo No. 3, which lies 440 meters west of No. 2, was drilled to a depth of 4060 ft. and abandoned as a dry hole on Jan. 2, 1944. Cantagallo No. 4, approximately 760 m. south of No. 2 was spudded in on Nov. 1, 1943, and completed as a producer on Sept. 21, 1944, at a total depth of 6885 ft. Its initial production was approximately 250 bbl. per day of 20.5° gravity oil. Cantagallo No. 5, which is 2500 m. southwest of No. 2, was spudded in on April 19, 1944, was drilled to 7059 ft., and abandoned as a mechanical failure on Sept. 21, 1944. Cantagallo No. 6, which is 660 m. northeast of Cantagallo No. 2, was spudded in on Oct. 25 and at the year's end it was drilling at 4600 feet.

Sindicato de Inversiones S.A. (Socony-Vacuum)

Floresanto No. 1, a wildcat being drilled by Socony-Vacuum and Tropical Oil Co. on this company's Pena concession, lies in the drainage area of the Sinu River, approximately 40 km. southwest of Monteria. It was spudded in on May 25 and at the year's end was drilling at 4800 ft. Good showings of high-gravity oil were encountered at shallow depth shortly after spudding in.

Richmond Petroleum Company of Colombia

El Retiro No. 1 well, on Richmond's El Doce concession, Department of Magdalena, drilling of which was commenced in 1943, was abandoned as a dry hole on March 16, 1944, at 5802 ft. in beds of Oligocene age.

El Retiro No. 2 well, also on the El Doce concession, started drilling May 10, 1944, in the Miocene, and was abandoned as a dry hole June 10, 1944, at 1525 ft., in beds of Oligocene age.

A well known as Chorrea Manteca No. 2 was spudded in on the Chorrea Manteca property, Department of Caldas, in the upper Magdalena Valley, Nov. 29, 1944. It started in beds of Miocene age and on Dec. 29, 1944, it had reached a depth of 2723 feet.

At the end of the year, steps were being taken to drill a test well on the Arroyo Caraballo concession, Department of Magdalena, in the Caribbean coastal region. The Arroyo Caraballo concession, with an area of 43,500 ha., was issued as of Feb. 9, 1944.

The Jaime Gutierrez concession, containing 24,672 ha., was transferred during the early part of the year to Compania Colombiana de Petroleo Tolima, S.A.

The El Doce concession, comprising 18,514.47 ha. in the Department of Magdalena, on which the El Retiro tests were drilled, was surrendered by Richmond during November 1944.

The Villamizar concession in the San Pablo area, Department of Bolivar, with an area of 15,121.9 ha., was relinquished by Compania Colombiana de Petroleo Occidental in July 1944.

Petroleum Developments in Ecuador 1941 through 1944

By Ben F. Zwick,* Member A.I.M.E.

The entire production of oil in Ecuador so far has come from the Santa Elena Peninsula, Province of Guayas. Both the shallow fields of the northern and the deeper fields of the southern part of the peninsula have been in constant exploitation, though the former are of doubtful economic value. In Table 1 herewith, which commences with the total amounts produced by the various companies up to 1940, annual company totals are given for the succeeding years. The figures for 1944 have been partly estimated. Table 2 gives figures on casinghead gasoline.

Shell Company of Ecuador (formerly known as Anglo-Saxon) has continued active exploration in the Oriente region east of the Andes, and during 1944 the Company's first wildcat well was spudded in.

International Ecuadorean Petroleum Co. (formerly International Petroleum Co., Limited) has pursued an active exploration campaign since the latter part of 1939, and a drilling string was placed in operation about a year later. A second string of tools was added during 1943 and a third a few months ago. Ten wildcats, all dry, have been completed in this period, two wells are drilling at the present time and other locations are on the program. Seven of the wells thus far drilled are in the area between Guayaquil and the Santa Elena Peninsula, one up the Daule River beyond Balzar, one on Puná Island in the Guayas Estuary and one in the northern province of Esmeraldas. Both the present drilling wells are in the Guayaquil-Santa Elena zone.

The situation in regard to concessions has changed during the past four years because I.E.P.C. has made its selections from the extensive Daule-Guayas Study Concession, as a result of which large tracts were returned to the Government; because of the expropriation of the holdings of the "Ecuapetrol," a German concern whose acreage has passed into other hands; the Peruvian-Ecuadorean boundary settlement, which has reduced Shell's holdings somewhat; and the transfer of most of the holdings of the Cia. Minero-Petrolera del Pacifico to I.E.P.C. The greater part

Manuscript received at the office of the Institute April 12, 1945.

* General Manager, International Ecuadorean Petroleum Co., Guayaquil, Ecuador.

Table 1.—*Production of Crude Oil in Ecuador*

Year	Anglo-Ecuadorian Oilfields	Ecuador Oilfields	Carolina Oil	I.E.P.C.	Concepción Ecuador	Petropolis Oil	Total
Total to 1940	23,041,639[b]	744,177	620,652	9,690	145,914	31,872	24,593,944
1941	1,103,873[b]	350,076	63,198	688	65,538	17,277	1,600,650
1942	1,704,399[b]	396,446	60,499	494	95,774	85,019	2,342,631
1943	1,711,492[b]	372,083	45,264	695	78,441	170,965	2,378,940
1944[a]	2,150,000[a,b]	581,000[a]	36,100[a]	700[a]	82,100[a]	130,100[a]	2,980,000[a]
	29,711,403[b]	2,443,782	825,713	12,267	467,767	435,233	33,896,165

[a] Estimated.
[b] Includes Ecuador Tropical Oil Co.

FIG. 1.—PETROLEUM CONCESSIONS IN ECUADOR.

of the Shell acreage is subject to selection, and the majority of the area involved reverts to the Government.

Standard of California and, to a lesser extent, Standard of New York, have at various times during the past few years shown a good deal of interest in the acquisition of acreage in Ecuador, and it is possible that the former, which still maintains a small organization within the country, may at some time enter the field on a more definite basis.

The accompanying map shows the present distribution of acreage in Ecuador.

TABLE 2.—*Casinghead Gasoline, Anglo-Ecuadorian Oilfields, Limited*

Year	Gas Treated, Cu. Ft.	Net Production, Gal.
Total to 1940	9,876,020,000[b]	7,665,693
1941	1,496,501,000	1,221,228
1942	1,896,157,000	1,542,269
1943	1,730,299,000	1,431,014
1944	2,149,400,000[a]	1,574,000[a]
	17,148,377,000	13,434,204

[a] Estimated.
[b] Partly estimated.

Petroleum Production in Mexico during 1943 and 1944

By J. M. de la Garza Cardenas,* Member A.I.M.E.

Mexico's total oil production in 1943 amounted to 35,149,843 bbl. and in 1944 to 38,196,818 bbl., both being substantially larger than in 1942, when production was only 34,715,547 bbl. Daily average figures are as follows: 95,111 bbl. in 1942; 96,301 bbl. in 1943; and 104,363 bbl. in 1944. The increase of 8062 bbl. in daily output from 1943 to 1944 was due to more refinery runs and an expanded volume in exports of refined products, although the export of crude oil decreased somewhat. The increase affected mainly the southern Tampico district (Golden Lane), which in December

Manuscript received at the office of the Institute April 28, 1945.
* Production Manager, Petroleos Mexicanos, Mexico, D. F., Mexico.

Table 1.—*Oil and Gas Development in Mexico in* 1944

Line Number	Field[a]	Year of Discovery	Area Proved, Acres[b]	Total Oil Production, Bbl.[c]		Gas Production Thousand Cu. Ft.		Number of Oil and/or Gas Wells		
				To End 1944	During 1944	To End 1944	During 1944	Completed to End 1944	1944 Completed	1944 Abandoned
	Northeastern Mexico									
1	La Presa	1934	x	0	0	3,082	145	3	0	0
2	Laredo	1937	70	0	0	0	0	3	0	0
3	Mier	1936	x	0	0	14,499	1,019	6	0	0
4	Rancherías	1933	1,230	0	0	13,337	300	7	0	0
	Tampico Area									
5	Poza Rica	1930	15,851	213,543,090[2]	21,019,040[2]	223,375[2]	22,127[2]	51	5	0
6	Northern District (Ebano, Panuco, etc.)	1904	100,000	767,154,890	3,636,768	x	x	1,659	5	x
7	Southern District (Golden Lane)	1908	33,000	1,051,007,957	8,292,043	x	x	544	0	x
8	Other Fields (San Sebastian, Tanhuijo, Mecatepec, Furbero).			4,082,967	22,159	x	x	55	0	x
	Isthmus of Tehuantepec Area									
9	Cuichapa	1934	300	891,307	229,460	x	x	8	3	0
10	El Burro	1930	370	14,860,778	491,965	x	x	41	0	0
11	El Plan (lignitic hor.)	1931	830	48,697,317	2,143,986	x	x	74	1	0
12	El Plan (Concepcion hor.)	1943	250	1,206,447	979,969	606	495	12	10	0
13	El Plan (eastern ext.)	1934	80	611,599	30,599	x	x	2	0	0
14	Filisola	1921	460	20,215,691	341,982	x	x	81	0	0
15	Teapa Nuevo	1928	40	202,150	27,707	x	x	8	0	0
16	Tonala	1928	470	42,890,883	972,856	x	x	93	0	0
17	Other Fields (San Cristobal, Capoacan, Soledad, Concepcion, Tecuanapa, Ixhuatlan, Belem, Sarlat, etc.).			x	8,284	x	x			
18	Total			2,165,365,076	38,196,818	254,899	24,086			

[a] Footnotes to column heads and explanation of symbols are given on page 258.
[2] Includes one well completed in Tertiary sand with 106,584 bbl. of oil. and 54 millions cu. ft. of gas total production.

1942 was producing less than 4000 bbl. per day, while in 1943 it went up to 17,820 bbl. and in 1944 to 22,718 bbl. per day.

Drilling

Throughout 1943, of the 22 wells drilled in Mexico, 9 were in the Tampico Northern district, 5 in Poza Rica, 4 in El Plan, 1 in Cuichapa and 3 wildcats; of these, 13 were productive. Of the 9 dry holes, 3 were wildcats and 6 in the Tampico Northern district, where production is found in fractures and a large percentage of failures is expected.

In 1944, of the 34 wells drilled, 11 were in the Tampico Northern district, 5 in Poza Rica, 11 in El Plan, 3 in Cuichapa and 4 wildcats; of these, 24 proved productive. Of the 10 unproductive wells, 6 were in the Tampico Northern district and 4 were wildcats.

Wildcats

During 1943, three exploration wells were drilled in search of new reservoirs, all of which were failures: Rancho Nuevo 1 in the Tampico district, close to the Golden Lane; Santa Ines 1, west of Tampico, which was abandoned because

TABLE 1.—(*Continued*)

Line Number	Wells Producing Dec. 1944[g1]: Oil: Flowing	Wells Producing Dec. 1944[g1]: Oil: Artificial Lift	Wells Producing Dec. 1944[g1]: Gas	Reservoir Pressure, Lb. per Sq. In.[h]: Initial	Reservoir Pressure, Lb. per Sq. In.[h]: Average at End of 1944	Character of Oil[i]: Gravity A.P.I. at 60°F.	Character of Oil[i]: Sulphur Per Cent	Producing Formation: Name and Age[j]	Producing Formation: Character[k]	Producing Formation: Porosity, Per Cent[l]	Producing Formation: Depth to Top of Producing Zone, Ft.[m]	Producing Formation: Productive Thickness, Ave. Ft. Net[n]	Producing Formation: Structure[o]	Deepest Zone Tested to End 1944[p]: Name	Deepest Zone Tested to End 1944[p]: Depth of Hole, Ft.
								NORTHEASTERN MEXICO							
1	0	0	3	700	x			Mount Selman, Eoc	S	15	1,925	38	A	Carrizo	5,960
2	0	0	3	320	x			Mount Selman, Eoc	S	20	720	12	AF	Carrizo	2,000
3	0	0	6	900[3]	900			Mount Selman, Eoc	S	23	2,120	x	N	Carrizo	2,935
4	0	0	7	860	x			Fayette, Cook Mountain, Yegua, Eoc	S	27	264	310	A	Mt. Selman	6,280
								TAMPICO AREA							
5	37	0	0	3,294	2,726	30	1.8	Tamabra, CreL	L	10x	7,250	296	N	Triassic	8,499
6	299	0	0	x	x	12	5.02	Tamaulipas, San Felipe, CreL	L	Fis	1,148	x[4]	AF	L. Cretaceous	4,182
7	198	0	0	x	x	20	3.64	El Abra, CreL	L	Cav	2,200	x[5]	AF	L. Cretaceous	10,585
8	1	0	0	x	x										
								ISTHMUS OF TEHUANTEPEC AREA							
9	8	0	0	800x	650	30	1.6	Concepcion Inf, Mio	S	x	2,100	33	DF	x	4,156
10	0	24	0	x	x	26	1.5	Concepcion Inf, Encanto, Mio	S	x	2,460	62	DS	Oligocene	5,423
11	4	35	0	x	x	24	2.0	Cedral, Lignitic, Mio	S	x	1,970	216	AF	Miocene	6,191
12	12	0	0	2,700	2,600	30	x	Concepcion Inf, Concepcion Sup, Mio	S	x	5,734	131	DX	Miocene	6,698
13	0	1	0	x	x	35	1.45	Concepcion Inf, Encanto, Mio	S	x	3,883	32	NF	Miocene	5,327
14	0	40	0	x	x	22	3.42	Encanto, Mio	S	x	1,585	92	TF	Miocene	3,608
15	0	0	0	x	x	36	1.15	Encanto, Mio	S	x	429	29	DS	Miocene	1,733
16	0	76	0	x	x	28	1.6	{ Concepcion Inf, Encanto, Mio / Deposito, Olig }	S	x	1,640	167	DS	Eocene	4,287
17				[illegible]	x										
18															

[1] Does not include wells temporarily shut down.
[3] Refers to deepest sand.
[4] Production found in fractures into the first 800 ft. of the Tamaulipas and San Felipe formations.
[5] Reef-phase limestone penetrated only 2 feet.

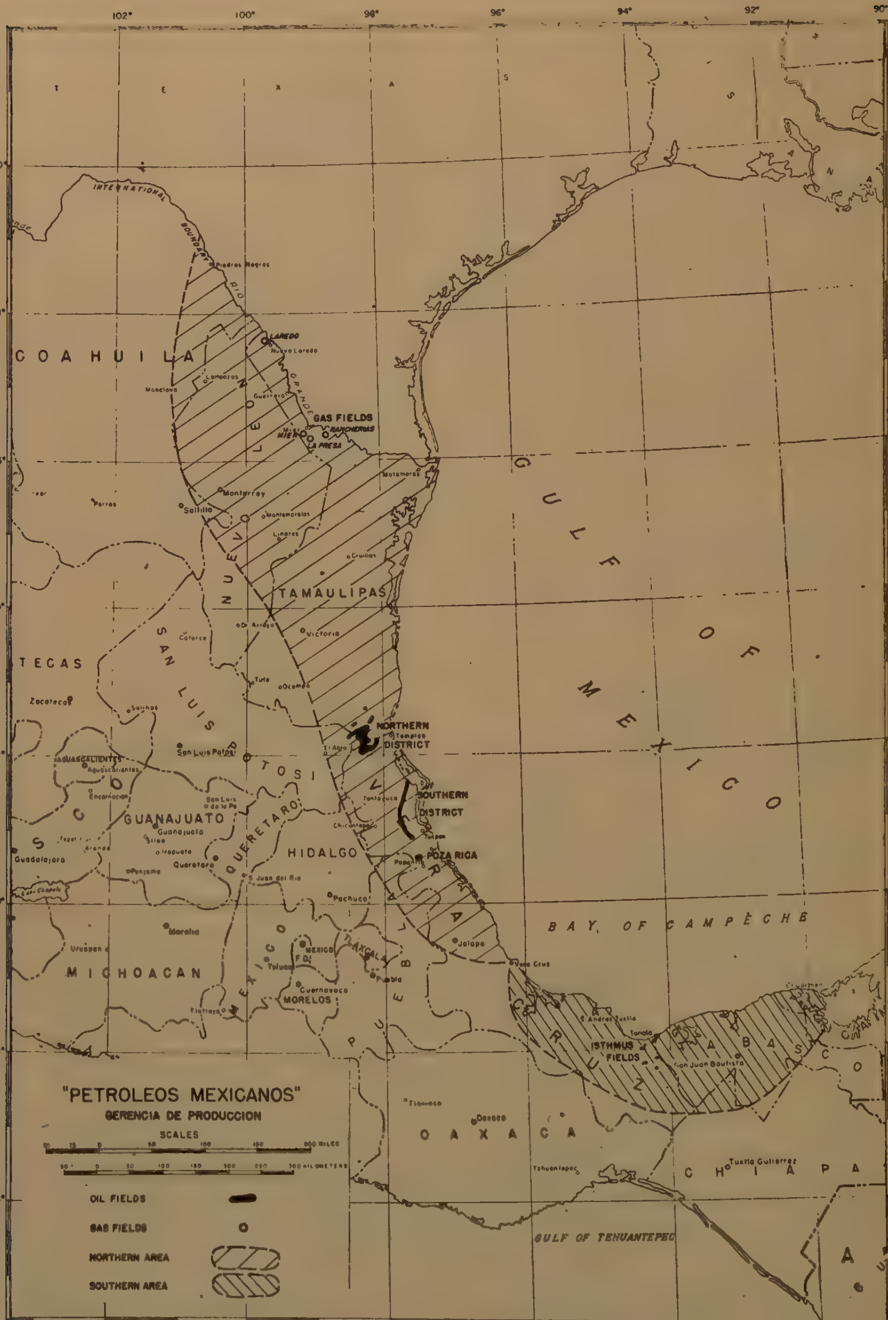
"PETROLEOS MEXICANOS"
GERENCIA DE PRODUCCION
SCALES
OIL FIELDS
GAS FIELDS
NORTHERN AREA
SOUTHERN AREA
GULF OF MEXICO
BAY OF CAMPECHE
GULF OF TEHUANTEPEC
COAHUILA
NUEVO LEON
TAMAULIPAS
SAN LUIS POTOSI
GUANAJUATO
QUERETARO
HIDALGO
MICHOACAN
MORELOS
OAXACA
GAS FIELDS
NORTHERN DISTRICT
SOUTHERN DISTRICT
POZA RICA
ISTHMUS FIELDS

FIG. 1.

of mechanical difficulties, and La Venta 1 in the Isthmus.

In 1944, only 4 wells were drilled: Aragon 2, west of the Golden Lane, Tampico area, and Santa Ines 2, west of Tampico; Zanapa 1 and La Venta 2 in the Isthmus. All were dry holes.

Operating Technology

Continued progress has been achieved and sound principles of petroleum engineering are being constantly applied in the development and proper handling of oil fields in Mexico. Electric coring, gun-perforating, squeeze-cementing and acidizing have become standard procedures and bottom-hole pressure surveys are being made periodically in all the new fields, such as the deeper productive sand in El Plan, Isthmus of Tehuantepec, Cuichapa and Poza Rica. In these new fields production is being curtailed to increase the ultimate recovery by taking advantage of the water drive present in them, wherever it is economically possible to do so.

New Refining Facilities

Additional refining facilities are being built in the Mexico City (Atzcapotzalco) refinery to increase its present capacity of 20,000 bbl. up to 40,000 bbl. per day, and to obtain aviation gasoline as well as high-test motor gasoline. In connection with this project, a desalting stabilization and absorption plant is being erected at Poza Rica and the capacity of the Poza Rica-Mexico City pipe line is being enlarged so as to enable it to supply the new refining facilities in Mexico City. It is expected that practically all of this new construction work will be completed before the end of 1945.

Plans for 1945

The production of oil in 1945 will be greater than that of the preceding years. The Government intends to increase exploration and drilling; wildcats will be drilled in northeastern Mexico, Tampico and Isthmus areas, while the exploitation wells in the Ebano, Panuco, Poza Rica, El Plan and Cuichapa fields will be kept going.

Acknowledgment

Mr. A. Moran, of the Production Department, Petroleos Mexicanos, greatly assisted the writer in the compilation of statistical data.

Petroleum Developments in Peru, 1942–1944

By O. B. Hopkins,* Member A.I.M.E.

The reports for the years 1942 and 1943 were written in 1943 and 1944, respectively, and were summarized at the meetings of the Institute in February 1943 and February 1944, but were held in manuscript form until released for publication in 1945.

1942

During the year 1942, developments in the Peruvian oil industry continued to be subject to repercussions from the swelling war effort, which steadily diverted more of the normal supply of men and materials into war channels, and necessitated the rerouting of supply lines. The result in Peru was an increasing demand for crude oil and products.

The production of petroleum in Peru in 1942 was 13,626,259 bbl., as compared with 11,935,584 bbl. in 1941—an increase of 1,690,675 bbl., or approximately 14 per cent. The largest increase, amounting to over 61 per cent, was from the Lobitos fields, but this increase was caused largely by the subnormal production in 1941. International Petroleum Company's production in the La Brea y Parinas field increased 727,111 bbl., or 7 per cent, whereas the Peruvian Government's production in the small Zorritos field declined 10,380 bbl., or approximately 20 per cent. The final production figures for the Ganso Azul field at Agua Caliente were not available for 1942 at the end of the year, but the production was believed to have increased approximately 80 per cent from 1941, or from 13,750 to approximately 25,000 barrels.

Development and Exploration

Exploration in Peru in 1942 was very limited and confined to areas adjacent to the older producing fields, and the efforts there were largely expended in the extension and development of the producing areas. This situation resulted partly from the shortage of transportation and drilling equipment, and also from the strong demand for increased production of oil.

International Petroleum Co. completed 69 wells during the year, including seven exploratory wells, three of which added moderate extensions to the proven areas. Sixty of the completions were oil wells and nine were dry holes.

Lobitos Oilfields, at Lobitos and Restin, is understood to have concentrated its drilling effort on development rather than on exploration.

The Peruvian Government operating at Zorritos confined its drilling to the development of the small producing areas previously found. During the year it announced plans to drill three exploratory wells in the Pirin area of southern Peru (see map on p. 638). It was reported that the Government had made a survey of the Sechura area (representing the southern part of the Northern National Reserve as shown on the map), but no work under this arrangement was announced.

The Cia. Ganso Azul, at Agua Caliente, completed its No. 6 well as a producer on March 27, and during the year it completed the installation of a 400-bbl. topping plant.

Manuscript received at the office of the Institute April 13, 1945.
* Vice President, Imperial Oil Limited, Toronto, Ont., Canada.

Leasing in 1942

There was very little leasing activity during the year 1942 and it appeared that the Government was taking a strong and nationalistic attitude with regard to the petroleum industry, and contemplated control of future exploration and development largely on its own account. This conclusion was indicated by such action as the creation of National Reserves covering prospective areas and the making of the contract for geophysical work in the Sechura area mentioned above, and by the refusal of various applications for petroleum concessions.

In connection with the latter, the following Governmental action may be considered significant. The applications of Sr. Castaneta for concessions covering 127,925 hectares in eastern Peru were reported to have been refused, and an application made by Sr. Checa has not as yet been accepted. When the Cia. Ganso Azul made application for the conversion to an exploitation basis of its exploration concessions covering 36,000 hectares, the Government took the attitude that it was not obligated to make such a conversion and, after imposing severe obligations on the Company, it agreed to the conversion of only 30,000 hectares, and caused the remaining 6000 hectares to be thrown into the reserved area. Under the agreement the Company was obligated to pay the Government, in addition to the royalty stipulated, 10 per cent of the profits. The Government assumed control over the selling price of crude and products and required that two members of the Company's directorate should be appointed by the Government.

It appears, however, that the Government may still grant petroleum concessions under certain conditions. An exploration concession in the High Sierras covering 4000 hectares was granted to Srs. Criado y Tejada by resolution dated Sept. 3, 1942, and applications of Srs. Barreda y Laos and Sr. Matteucci, covering 150,456 hectares, appear to be in the way of being approved provided they are adapted to conform to Law 8527 with regard to location and area.

Other Developments in 1942

An important event of the year was the change in the exportation tax which, as of March 1, was increased from $1.705 U.S. Cy. per metric ton to $2.96. This is approximately equivalent to an increase from 22.6¢ to 39.27¢ per barrel. Royalty payments, however, may be deducted from the export tax payable.

Another important event was the settlement of the boundary between Peru and Ecuador, which was agreed to during the Pan American conference in Rio de Janeiro on January 29. Incidentally, the settlement reduced the Anglo Saxon Oil Company's 10-million-hectare concession in Ecuador by about 6 per cent which, according to the decision, lay in Peruvian territory.

1943

Exploration activities in Peru continued to be strongly affected by the difficulty of securing men and equipment from the reduced supply that remained available after the demands of the war effort had been satisfied.

Exploratory Drilling

In order to make the most of the transportation equipment that was on hand, exploratory drilling in 1943 was mostly confined to the older, nearer and more accessible areas.

International Petroleum Co., on its La Brea-Parinas Estate, completed 14 semiexploratory wells. Three of these added modest extensions to the proven oil areas; three were productive of gas only, and eight were abandoned as dry holes.

The Lobitos Oilfields Ltd. likewise concentrated its drilling effort on develop-

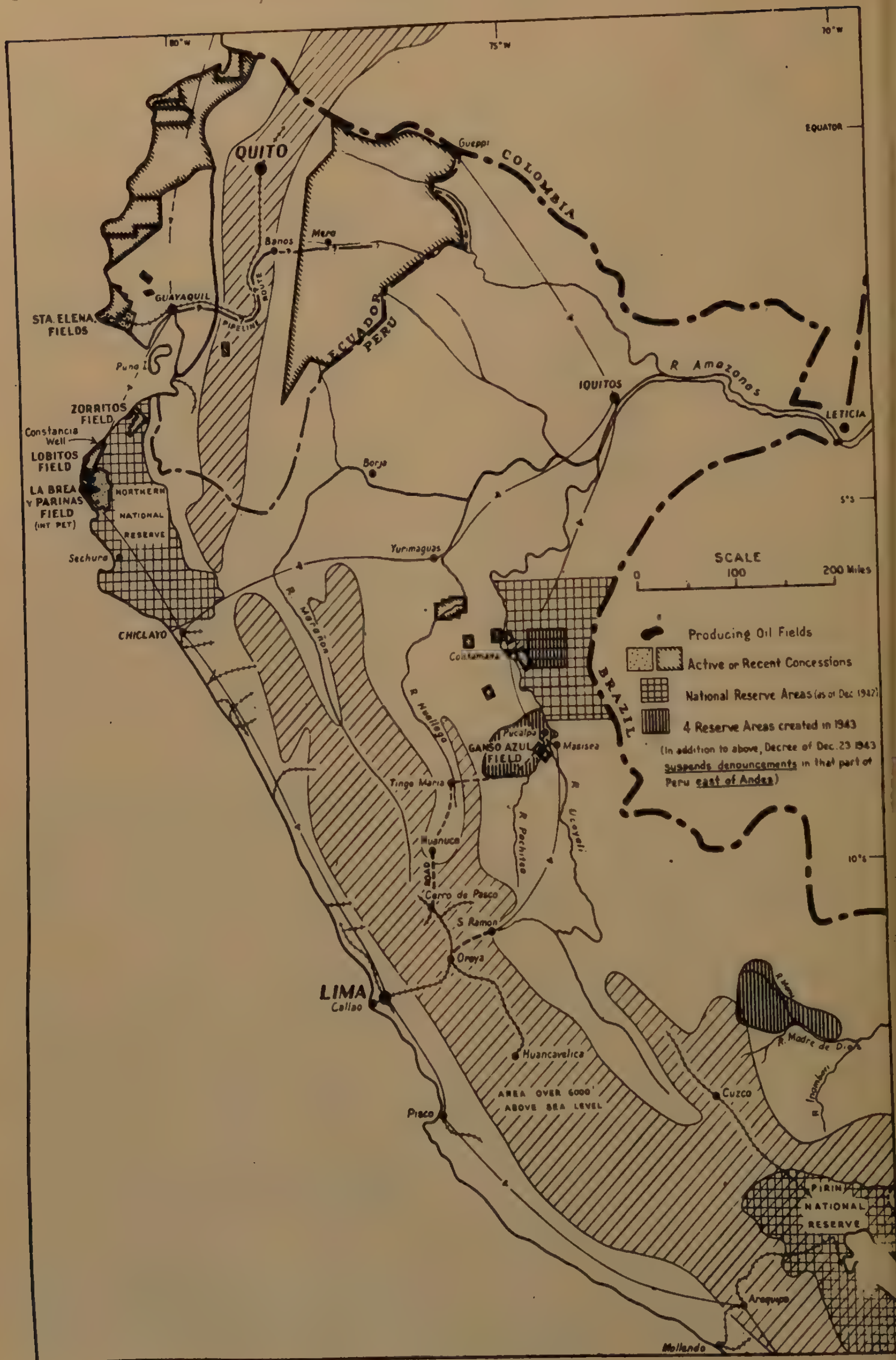

FIG. 1.—OIL FIELDS OF PERU.

ment wells in the proven areas of its property, which adjoins International's Estate on the north. It is understood that no wildcat drilling of any kind was undertaken by this company during the year.

The Peruvian Government is reported to have drilled an outlying wildcat well south of Zorritos on a part of the Tumbes National Petroleum Reserve, which originated from several small renounced leases. This well is known as Organos No. 7 and is on an old, renounced lease known as Constancia, which is entirely surrounded by lands held by the Lobitos Oilfields. The test is said to have completed as a producer that flowed at the rate of 70 bbl. per day from a depth of approximately 500 meters.

In eastern Peru the Cia. Ganso Azul, it is understood, did not complete or commence drilling on any wells on its Agua Caliente concession in 1943, probably because the market outlet for its products is so restricted under present conditions that the production available from wells already drilled is ample to take care of the current demands for products.

Surface Exploration

On Aug. 14, by Supreme Resolution 328, the Government authorized Engineer Broggi to compile a geologic map of Peru. A few months later, it formally approved a plan he had submitted for the initiation of the work and for making the geologic studies necessary to evaluate properly the potentialities of the Amazonian region, and also to cooperate with neighboring countries in making a geologic map of South America. The geological prospecting was expected to be completed by the end of 1943 for the Departamentos of Cuzco, Madre de Dios and the upper part of Loreto.

Table 1.—*Production of Crude Oil in Peru*, 1940–1943
Barrels[a]

	La Brea-Parinas (International Petroleum Co.)	Lobitos & Restin (Cia. Petrolera Lobitos)	Zorritos (Petroleo del Estado)	Pachitea (Cia. Ganzo Azul	Total
1940	9,626,831	2,431,477	67,957		12,126,265
1941	10,362,395 (2160)[b]	1,507,208 (794)	53,231	13,750	11,936,584
1942	11,089,506 (2202)	2,469,902 (800)	41,850 (51)	27,201 (4)	13,628,459
1943	12,055,908 (2239)	2,529,232 (815)	39,766 (51)	29,592 (4)	14,654,498
Wells Drilled in 1942					
Number of wells completed	69	22	6		97
Producing	60	20	3		83
Dry holes	9	2	3		14
Total feet drilled in year	230,389	53,079	7,917		290,385 ft.
Wells Drilled in 1943					
Number of wells completed	72	37	3		112
Producing	59	18	2		79
Dry holes	13	19	1		33
Total feet drilled in year	272,032	57,188	8,113		337,263 ft.

[a] Peruvian Government statistics from Anuario de la Industria Minera en el Peru 1943, 170–176, Pub. Lima, Peru, Sept. 1944.
[b] Figures in parentheses indicate number of wells.

Leasing

Throughout the country, as far as known, no changes were made in 1943 in the status of concessions already granted nor were any large concessions applied for during the year.

In eastern Peru, more restr ctions were placed on the filing of applications for concessions. As of Jan. 13, the Government, in four separate Resolutions, created four new Reserved Areas; three in the Departamento of Loreto and the other in the district of Manu, on the headwaters of the Madre de Dios River. These new Resolutions were followed on Dec. 23 by a new decree, under which there was suspended until further notice the acceptance of any oil

denouncements throughout the entire region of eastern Peru. The grounds given for this action were that the Government is studying a plan for the exploration and exploitation of the oilfields in the whole area east of the Andes. The locations of all these restricted areas are noted on the accompanying map.

1944

In 1944, exploration in Peru was confined essentially to the drilling of 20 wildcat and stepout wells by established companies in the oil fields on the Coast, and to some surface geological investigations that were made for the Peruvian Government in the Oriente region of eastern Peru. The areas of activity during 1944 are shown on the map on p. 638.

Exploratory Drilling in 1944

Largely because of the conditions of insistent demand for oil and reduced supply of materials that were imposed by the war, the exploratory drilling was restricted to close-in areas where any new discovery wells would be relatively cheap and easy to drill and could be connected immediately with production outlets.

International Petroleum Co., which produces about 82 per cent of Peru's annual output, completed 19 exploratory or semiexploratory wells. Of these, four resulted in discoveries of oil, one produced gas, and 14 were abandoned as dry holes. The four new pools probably will prove to be relatively small areally, as often happens on the Estate. However, usually this characteristic is offset considerably by the richness of the sands, so that any discovery well makes a satisfying addition to the proven reserves; and production by natural flow provides new oil that is quickly available, without waiting for pumping equipment.

The Lobitos Oilfields, which operates the adjoining property to the north on the coast, and usually produces 17 per cent of the country's annual production, is understood to have conducted little or no exploratory drilling in 1944, presumably preferring to devote its activities to supporting its output by drilling only development wells in proven areas and doing some deepening.

The Peruvian Government, on its small Constancia property, which lies completely surrounded by the Lobitos tract, is reported to have completed during the year a second well, known as Organos No. 8, as a stepout to the discovery well Organos No. 7, which came in during late 1943 at 70 bbl. per day or better. The new well is rated as capable of flowing about 40 bbl. per day. No new activity of importance has been reported on or near the Government's Zorritos property or elsewhere in the reserve zone of northern Peru.

In eastern Peru the Government is said to be preparing to drill a test well with a rotary rig on a structure in the Orellana district of the Contamana region, where Mr. Douglas Fyfe, formerly of the Ganso Azul, has been in charge of the geological investigation. Orellana is some 350 km. north of the Ganso Azul field.

Surface Exploration

The Government has commissioned Dr. Victor Oppenheim also to do geological work for it. At midyear, Dr. Oppenheim, who formerly worked with the Socony-Vacuum Co., was studying the oil possibilities in the Rio Manu area in southeastern Peru, where his field party expected to work on regional stratigraphy and structure in the area above the Manu's confluence with the Upper Madre de Dios.

Leasing and Lease Legislation

Leasing was again very inactive during the year. It may be recalled that the Government on Jan. 13 of 1943 created restricted areas in the Department of Loreto and in the Manu region; and that

on Dec. 23 of the same year, it issued a decree preventing the filing of applications anywhere in eastern Peru until further notice. Recently—that is, on Jan. 18, 1945—it issued another decree reserving all the oil lands in the coastal departments of Peru. As a result of these and earlier decrees, relatively little prospective oil land in Peru is now open to filing.

As far as the general trend of leasing legislation in Peru is concerned, it is said that consideration is being given to the drafting of a new oil law, early action on such a law being favored by some and others preferring to delay the drafting of new legislation until the end of the war and more settled conditions indicate what new features should be incorporated in a new law.

Meanwhile, in adjoining Ecuador, the International and Lobitos interests carry on exploration and exploitation, respectively, along the coast, and the Anglo-Saxon continues the investigation of its huge concession covering the entire Ecuadorian Oriente.

Petroleum Developments in Venezuela 1941 to 1944 Inclusive

By D. C. Porterfield*

1941

Production of crude oil in Venezuela increased from 186,134,000 bbl. in 1940 to 228,131,000 bbl. in 1941, or 22.6 per cent, to establish a new all-time high for the country. While the average production for the year was 625,000 bbl. per day, production during the month of December 1941 averaged 751,000 bbl. per day, and during the last week of the year, 766,000 bbl. per day.

Production from the Lake Maracaibo basin averaged 454,000 bbl. per day during the year, or 72 per cent of the total for the country, compared with 73 per cent of the total produced in 1940.

Drilling during the year was approximately on the same scale as in 1940, with 438 wells completed in 1941 as compared with 429 the year before. Exploratory completions decreased from 18 in 1940 to 6 in 1941. Of the drilling operations in 1941, 56 per cent was concentrated in the Lake Maracaibo basin and 44 per cent in eastern Venezuela, success being 98 per cent in the Lake basin and 83 per cent in the east. Successful completions for the country as a whole amounted to 92 per cent of the total wells drilled.

Exploratory drilling in 1941 resulted in the discovery of three new fields, all in eastern Venezuela; viz., Guara, about 11 km. to the northeast of the Oficina field but on a separate structure; Santa Rosa, which is east of El Roble field on a structure forming a part of the major Santa Ana-San Joaquin-El Roble uplift; and Santa Barbara, which is southwest of the Jusepin field on an extension of the main Jusepin anticline. At the close of the year three wildcats were drilling, all of which showed prospects of obtaining production; that is, Mercedes No. 2 in central Guarico, Las Ollas No. 1 on the Anzoategui-Guarico border near the town of Zaraza, and Quiamare No. 1 in Anzoategui northeast of the town of San Mateo.

In spite of heavy withdrawals and the resultant natural decline in the potentials of older producing areas, new drilling during the year increased the potential production of the country from an estimated 780,000 bbl. per day at the end of 1940 to an estimated 810,000 bbl. per day at the end of 1941, or approximately 4 per cent.

Since domestic consumption of petroleum products is insignificant compared with total production, exports of crude and products during the year increased in line with production. Crude exports totaled 196,800,000 bbl., compared with 158,400,000 bbl. in 1940, and exports of products were 26,100,000 bbl., compared with 21,900,000 bbl. the year before.

Exports of crude from Venezuela to the United States amounted to 36,500,000 bbl. In addition, about 2,200,000 bbl. was imported in bond into the United States for transfer to Canada.

Total refining capacity of the country in 1941 was approximately 125,000 bbl. per day, including a crude-conversion plant with a capacity of 32,000 bbl. per day, capable of making fuel oil only. Three plants with a capacity of 121,000 bbl. per

Manuscript received at the office of the Institute June 11, 1945.
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day, out of a total of nine in the country, supplied products consumed locally with the exception of lubricants, waxes and aviation gasoline, and exported their surplus output.

The remaining six, which are small topping or conversion plants, furnished gasoline and fuel for the consumption of the companies operating them.

A total of approximately 31,000,000 bbl. of crude was refined in Venezuela during 1941 compared with 27,000,000 bbl. in 1940.

1942

Production during 1942 totaled 147,984,000 bbl., compared with 228,131,000 bbl. in 1941, or a decrease of 35 per cent. This decline in withdrawals was the direct result of the shipping situation that developed soon after the first of the year, when enemy submarine action against allied shipping in the Caribbean area was intensified. The 1942 production was the lowest for Venezuela since 1934.

The Lake Maracaibo basin continued to rank first among the producing areas of the country, with 1942 withdrawals amounting to 107,227,000 bbl., or 73 per cent of the total, compared with 72 per cent in 1941.

Total potential production available for export increased from approximately 800,000 bbl. per day in December 1941 to approximately 850,000 bbl. per day at the end of 1942, or about 6 per cent. Actual production at the end of the year 1941 amounted to 94 per cent of the potential compared with only 48 per cent at the end of 1942. The potential at the close of 1942 was divided; 64 per cent for the Bolivar Coastal fields, 12 per cent for other fields in western Venezuela, and 24 per cent for eastern Venezuela fields.

In spite of curtailed production during 1942, drilling was maintained at approximately the same level as in 1941. A total of 447 wells was completed in the country during the year, or 9 more than in 1941. Of all 1942 completions, 95 per cent were successful.

Exploratory drilling in 1942 resulted in the completion of 10 wildcat wells of which six were producers and four were dry holes. Two new fields of probably major importance were discovered; viz., Quiamare, in the state of Anzoatequi, to the northeast of the town of San Mateo, and Mercedes, which is in Central Guarico about 50 km. west of the town of Valle de la Pascua. In addition, crude accumulation of minor importance was discovered in wildcat wells Las Ollas No. 1, near the town of Zaraza at the eastern boundary of the state of Anzoategui, and OM No. 2, which proved the existence of a southeast extension to the Oficina field.

Exports of crude from Venezuela during 1942 amounted to 123,000,000 bbl., compared with 196,800,000 in 1941, and exports of products were 17,100,000 bbl., as compared with 26,100,000 bbl. the preceding year.

Crude exports destined for the United States amounted to 6,700,000 bbl. In addition, 3,000,000 bbl. was imported into the United States in bond for transfer to Canada.

A total of 22,202,000 bbl. of crude was refined in the country during 1942, compared with approximately 31,000,000 bbl. refined in 1941. As of the end of the year 1942 there were nine refineries in Venezuela having a total capacity of approximately 135,000 bbl. per day, including two plants processing heavy crude for the manufacture of fuel oil, with a total capacity of 42,000 bbl. of crude per day.

1943

On March 13, 1943, the Venezuelan Congress passed a new Petroleum Law, superseding all others previously enacted, which had a far-reaching effect on the oil industry. Companies already holding concessions when the law became effective were given the right to convert their holdings to the new law, and were granted

TABLE 1.—*Drilling and Production Summary of Proved Fields in Venezuela from 1941 to 1944*

Line Number	Fields	Production						Well Completions												Status of Wells, 12-31-44				
		Gravity Range	1941	1942	1943	1944	Cumulative Total to Dec. 31, 1944	1941			1942			1943			1944			Pro-duc-ing	Closed In	Inac-tive	Aban-doned	Total Drilled
								Oil	Gas	Dry	Oil	Gas	Dry	Oil	Gas	Dry	Oil	Gas	Dry					
1	Lake Fields	11°–30°	141,993,848	88,299,127	121,772,711	156,848,381	2,001,477,779	198		3	229		2	78		1	50		1	2,262	658	705	287	3,912
2	Caritos	31°	12,772	36,286	20,094	20,054	105,111			1											1		2	3
3	Concepcion	31°–42°	1,203,405	1,709,608	1,712,281	1,357,774	27,763,687	7			20		1	5		2	1		1	78	14	48	7	147
4	Cumarebo	43°–61°	2,069,285	403,051	1,740,155	2,095,762	32,461,450				[illegible]		1	1					2	52	8	49	17	126
5	El Mene	34°–36°	227,473	196,145	170,608	168,589	22,769,077													22		137	127	286
6	Guara	17°–45°		10,596	698,007	8,221,970	8,935,493				2			9		2	53		1	62	1	5	10	78
7	Guario	39°–41°	109,346	128,175	94,882	722,136	1,069,956	2			2			2			3			8		2		10
8	Guico	20°–45°				305,338	305,338										2			1	1			2
9	Hombre Pintado	18°–28°	562,831	471,562	416,879	289,334	3,256,170	5			5			2						22		21	6	49
10	Jusepin	27°–35°	7,197,882	7,143,306	6,329,072	11,365,880	36,547,410	40		2	24		1	2		1	63		3	85	94	5	7	191
11	La Paz	15°–28°	417,366	309,750	1,102,776	3,642,348	11,146,766				3			14		2	24		1	58	4	9	7	78
12	Leona	15°–40°	82,298	367,155	854,790	1,389,160	2,711,185	9		1	10		3							1	18	2	4	25
13	Las Mercedes	35°		5,531	10,876	529	16,936						1	3		3					4		3	7
14	Los Manueles	28°–34°	3,650,204	3,075,255	3,500,390	3,088,399	33,888,327	4			4		1							19		12	3	34
15	Media	40°–43°	17,455	13,144	554		2,627,545															22	16	38
16	Mene Grande	15°–33°	12,496,698	10,240,389	10,651,138	11,701,610	265,452,860	21			23		1	6		1	3		3	242	44	177	28	491
17	Mulata	28°–36°		8,885	1,384,725	5,889,701	7,283,311	1	1		17	1		20		3	51	1	4	63	30		8	101
18	Netick	21°–29°	26,529	44,679	29,219	18,725	200,974			1			1			1	1				1	2	3	6
19	Oficina	15°–44°	24,465,405	12,190,191	9,707,156	14,563,372	78,877,946	86	4	13	21		3	4		1	13		2	153	9	81	48	291
20	Pedernales	19°–23°	1,584,432	273,440			9,036,014														11	3	5	19
21	Quiamare	39°		105,640	127,151	134,634	367,425													2				2
22	Quiriquire	11°–27°	20,568,628	14,036,692	7,045,491	11,919,650	225,826,334				4			1						161	67	59	15	302
23	Roble	42°–45°	1,777,342	2,361,764	1,685,869	2,167,430	8,648,609	3			5									9	1			10
24	San Joaquin	38°–47°	2,883,393	838,256	1,314,861	3,753,476	9,929,271	9		1	3		1				5		1	22	1	4	3	30
25	Santa Ana	34°–51°	181,816	41,676	69,218	271,471	675,383	1												2		1		3
26	Santa Barbara	24°–34°	33,093	359,988	3,556,767	10,617,849	14,567,697	8	1		31	2	2	18			40	3		101	2	2	3	108
27	Santa Rosa	39°–46°	218,012	382,032	364,047	676,109	1,640,200			1	2			1		1				4			3	7
28	Tarra	23°–29°	2,998,919	2,456,996	3,765,040	3,988,651	54,957,017	6		1	5		1	15		1	8	1	2	82	3	40	23	148
29	Temblador	18°–28°	3,300,488	2,456,216	1,237,235	1,086,786	18,081,600							1			2		1	4	65	9	16	94
30	Travieso	25°–35°				435,816	435,816										17			6	8	3		17
31	Yopales	25°–42°			23,263	135,220	167,465							3		2	3	1	3		3	4	7	14
32	Others		52,218	18,776	13,919	157,592	3,967,784	1		1	2					1				2	1	56	123	182
33	Total		228,131,138	147,984,311	179,399,174	257,033,746	2,885,197,936	401	6	25	415	3	19	185		22	339	6	25	3,523	1,049	1,458	781	6,811

new titles to all concessions thus converted to run for 40 years from the date of conversion. Royalties on production payable to the Government, which formerly ranged from 7.5 to 15 per cent, depending upon the location of the concessions and the petroleum law under which they had been granted, were uniformly raised to 16⅔ per cent. Surface taxes and initial exploration and exploitation taxes were also increased but it is generally conceded by the industry that the new law is eminently fair to both the concessionnaires and the Government. At the end of the year indications were that the industry in Venezuela was entering a period of greatly intensified activity. Beside the companies that have operated in Venezuela for a number of years, several additional American companies have recently been acquiring concessions and preparing to start preliminary exploration work.

TABLE 2.—*Wildcats Drilled in Venezuela*, 1941 *to* 1944

Line Number	Well Name	Drilled By	Location		Total Depth, Ft.	Results
			State	District		
	1941					
1	Oficina OS No. 13	Mene Grande Oil Co.	Anzoátegui	Freites	7,005	400 bbl. per day
2	Sta. Rosa RG No. 2	Mene Grande Oil Co.	Anzoátegui	Freites	6,577	1,460 bbl. per day
3	Sta. Barbara No. 1	Cia. Consolidada de Petr.	Monagas	Maturin	4,325	1,920 bbl. per day
4	Panchita No. 1	Socony-Vacuum Oil Co.	Anzoátegui	Monagas	3,606	Dry hole
5	Hamaca No. 1	Socony-Vacuum Oil Co.	Anzoátegui	Miranda	3,472	Dry hole
6	Mercedes No. 1	S.A.P. Las Mercedes	Guárico	Infante	6,232	Dry hole
	1942					
7	Guara GG No. 1	Mene Grande Oil Co.	Anzoátegui	Freites	8,096	1,260 bbl. per day
8	Guara GG No. 2	Mene Grande Oil Co.	Anzoátegui	Freites	7,889	500 bbl. per day
9	Oficina OM No. 2	Mene Grande Oil Co.	Anzoátegui	Freites	5,421	155 bbl. per day
10	Quiamare QG No. 1	Mene Grande Oil Co.	Anzoátegui	Libertad	9,055	685 bbl. per day
11	Mercedes No. 2	S.A.P. Las Mercedes	Guárico	Infante	5,586	1,500 bbl. per day
12	Las Ollas No. 1	Standard Oil Co. of Venezuela	Guárco	Zaraza	7,947	
13	Guara GS No. 1	Mene Grande Oil Co.	Anzoátegui	Freites	7,307	Dry hole
14	Guara GG No. 4	Mene Grande Oil Co.	Anzoátegui	Freites	7,400	Dry hole
15	Guara GM No. 1	Mene Grande Oil Co.	Anzoátegui	Freites	7,755	Dry hole
16	Cimara No. 1	Texas Petroleum Co.	Monagas	Sotillo	5,543	Dry hole
	1943					
17	Cumarebo C No. 123	Creole Petroleum Corp.	Falcon	Zamora	2,803	Dry hole
18	Pta. Benitez No. 145	Creole Petroleum Corp.	Zulia	Bolivar	4,925	Dry hole
19	Guara GS No. 4	Mene Grande Oil Co.	Anzoátegui	Freites	3,992	Dry hole
20	Oficina OM No. 3	Mene Grande Oil Co.	Anzoátegui	Freites	5,491	720 bbl. per day
21	Quiamare QG No. 2	Mene Grande Oil Co.	Anzoátegui	Libertad	9,710	50 bbl. per day
22	Yopales YS No. 2	Mene Grande Oil Co.	Anzoátegui	Miranda	5,500	230 bbl. per day
23	La Cruz No. 1	Creole Petroleum Corp.	Monagas	Maturin	9,539	Dry hole
24	Bachaquero LB No. 113	Venezuelan Oil Conc. Ltd.	Zulia	Bolivar	7,573	Dry hole
25	Concepcion No. 141	Venezuelan Oil Conc. Ltd.	Zulia	Maracaibo	5,542	Gas well
26	La Paz No. 53	Venezuelan Oil Conc. Ltd.	Zulia	Maracaibo	5,015	Dry hole
27	La Paz No. 55	Venezuelan Oil Conc. Ltd.	Zulia	Maracaibo	1,936	63 bbl. per day
28	Mene Grande No. 471	Caribbean Petroleum Co.	Zulia	Sucre	6,974	50 bbl. per day
29	Tarra No. 125	Colon Development Co.	Zulia	Colon	3,170	Dry hole
30	Tarra No. 131	Colon Development Co.	Zulia	Colon	3,672	Dry hole
31	Tarra No. 133	Colon Development Co.	Zulia	Colon	4,530	Dry hole
32	Manapire No. 1	S.A.P. Las Mercedes	Guárico	Infante	5,123	Dry hole
33	Soledad No. 1	Socony-Vacuum Oil Co.	Monagas	Maturin	9,550	Dry hole
34	Los Pobres No. 1	Socony-Vacuum Oil Co.	Anzoátegui	Monagas	3,925	Dry hole
	1944					
35	La Rosa L No. 186	Creole Petroleum Corp.	Zulia	Bolivar	5,438	Dry hole
36	Pta. Benitez PB No. 151	Creole Petroleum Corp.	Zulia	Bolivar	4,385	Dry hole
37	Boqueron No. 1	Creole Petroleum Corp.	Monagas	Maturin	9,825	Dry hole
38	La Cruz No. 2	Creole Petroleum Corp.	Monagas	Maturin	5,040	Dry hole
39	Guara GS No. 20	Mene Grande Oil Co.	Anzoátegui	Freites	7,201	525 bbl. per day
40	Guara GS No. 21	Mene Grande Oil Co.	Anzoátegui	Freites	6,805	495 bbl. per day
41	Yopales YS No. 11	Mene Grande Oil Co.	Anzoátegui	Miranda	5,600	150 bbl. per day
42	Yopales YS No. 14	Mene Grande Oil Co.	Anzoátegui	Miranda	4,973	380 bbl. per day
43	Bachaquero LB No. 114	Venezuelan Oil Conc. Ltd.	Zulia	Bolivar	10,000	Dry hole
44	Bachaquero LB No. 124	Venezuelan Oil Conc. Ltd.	Zulia	Bolivar	2,279	1,050 bbl. per day
45	Concepcion C No. 147	Venezuelan Oil Conc. Ltd.	Zulia	Maracaibo	2,716	Dry hole
46	Texas No. 2	Texas Petroleum Co.	Delta Amacuro		9,244	Dry hole
47	Merst No. 1	Texas Petroleum Co.	Guárico	Infante	4,945	Dry hole
48	Pericocal No. 1	Socony-Vacuum Oil Co.	Guárico	Zaraza	5,336	Dry hole
49	Pando No. 1	Mene Grande Oil Co.	Anzoátegui	Freites	6,900	Dry hole
50	DM No. 1	Caribbean Petroleum Co.	Zulia	Mara	6,000	Dry hole
51	Mercedes No. 7	Texas Petroleum Co.	Guarico	Infante	5,819	Producer

Production in Venezuela during 1943 was adjusted to meet war requirements and tied in with the availability of tankers. The total for the year was 179,399,000 bbl., or 21 per cent over the 1942 figure. The Maracaibo basin accounted for 81 per cent of the total, compared with 73 per cent in 1942.

Potential production for the country at the end of 1943 was estimated to be 880,000 bbl. per day, an increase of some 30,000 bbl. per day over the potential at the close of 1942.

Drilling was considerably curtailed during 1943, compared with 1942, principally because of material shortages. Only 222 new wells were completed in the country, or 50 per cent fewer than the previous year; 86 per cent of the 1943 completions were producers, compared with 95 per cent success obtained in 1942.

Eighteen exploratory wells were drilled in 1943, of which five were oil wells, one produced gas and 12 were dry. No new fields were discovered during the year but extensions of some importance were proved in the Concepcion, La Paz, Quiamare and Yopales fields.

Pipe-line facilities were completed in 1943 that permitted Santa Barbara, Mulata and Yopales fields to be produced for export for the first time.

A total of 174,150,000 bbl. of crude and products was exported from Venezuela during 1943, of which 156,700,000 bbl., or 90 per cent, was crude oil. Exports to the United States amounted to 11,050,000 bbl. of crude.

The total refining capacity of the country at the close of the year was approximately 135,000 bbl. per day. Crude throughput during the year amounted to 21,500,000 bbl., compared with 22,200,000 bbl. in 1942.

1944

The year 1944 was characterized by greatly increased activity within the industry as compared with the preceding two years. The clearing of the Caribbean area of enemy submarines permitted increased shipping, which resulted in the steady increase of production and exports throughout most of the period. Drilling was also stepped up as materials became more readily available.

Production in 1944 totaled 257,034,000 bbl., which was 43 per cent above the 1943 figure and the greatest in the history of the country. Peak production was reached in September when an average of 833,000 bbl. per day was produced during the week ended Sept. 25. Western Venezuela accounted for 183,200,000 bbl., or 71 per cent of the total, compared with 81 per cent in 1943. Potential production for the country at the end of the year was estimated to be some 960,000 bbl. per day, compared with 880,000 bbl. per day at the end of 1943, an increase of about 9 per cent.

Drilling in Venezuela during 1944 resulted in the completion of 387 wells, of which 89 per cent were producers. This total includes 17 wildcats, of which 6 were successful, and 12 deeper tests, of which 11 were producers. No new fields were discovered during the year but important extensions to known reservoirs were outlined, which added substantially to reserves.

Exports from Venezuela in 1944 totaled 249,950,000 bbl., of which 229,450,000 bbl. was crude and 20,500,000 bbl. was refined products. The bulk of all exports was shipped to the refineries at Aruba and Curaçao for refining or further processing. Exports to the United States amounted to 37,450,000 bbl., or only 15 per cent of the total.

Approximately 25,900,000 bbl. of crude was processed within the country during 1944. Domestic consumption amounted to approximately 7,600,000 bbl. of crude and products compared with 6,150,000 during 1943.

At the close of the year there were approximately 26,500,000 acres of oil concessions in force in Venezuela, held by 42 companies and individuals.

Chapter IV. Education

Petroleum Engineering Education and the Quantitative Approach

By Harry H. Power,* Member A.I.M.E.

(Houston Meeting, May 1944)

Abstract

The specific purposes of formal engineering education include training in the basic sciences, the engineering-problem method, the rudimentary development of technical skills, an appreciation of values and costs, and an understanding of the art of engineering as distinguished from its science. Two major divisions of an educational program in engineering are recognized: (1) the scientific-technological, and (2) the humanistic-social. Hence, the entire curriculum for the four-year program in specialized petroleum engineering schools must be designed to give the student an initial impetus in the directions indicated. In accordance with suggestions from the Engineering Council for Professional Development, more attention is being given to the fundamental approach in the undergraduate curriculum.

This paper presents a cross-sectional viewpoint of the various educators in the petroleum engineering schools concerning course contents in the specialized curricula. An outline is suggested for the content of the specialized courses wherein the engineering problem method or quantitative approach is emphasized. Although the particular viewpoints of the author have been stressed, yet due acknowledgment is made to a considerable number of petroleum engineering educators and engineers in industry interested in educational work, for their contribution of course outlines or helpful suggestions with respect to programs that will be of maximum value to students, institutions, and the industry they serve.

Although "standardization" of course material is not suggested, the advantage to be gained by cooperative determination of purpose and scope are apparent, particularly from the standpoint of the proper accreditment of petroleum engineering schools *by petroleum engineering educators* who have laid a basis from which to measure educational values. Petroleum engineering has "come of age" and deserves the same careful attention with respect to curricula that has been accorded other engineering branches.

Introduction

Engineering schools have a major responsibility to the public, to industry and to the professions they serve. The specific purposes of formal education include training in the basic sciences, the engineering-problem method, the rudimentary development of technical skills, an appreciation of values and costs, and an understanding of the art of engineering as distinguished from its science. Other purposes implied include the ability to read, write, and speak the English language effectively, an understanding of social and human relationships, a knowledge of the duties of citizenship, a broad appreciation of cultural interests, and an indoctrination in professional standards and relations. Throughout these educational processes is the development in the student of habits of accuracy, thoroughness, powers of analysis, creative ability and integrity with respect to all phases of his work.

Major Divisions of Program

In the Report of the Society for the Promotion of Engineering Education,† two

Manuscript received at the office of the Institute Dec. 5, 1944.

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† Report of Committee on Engineering Education after the War, dated January 1944.

major divisions of an educational program are recognized: (1) the scientific-technological and (2) the humanistic-social.

The objectives of the first division are:

"1. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:
   (a) grasp of the meaning of physical and mathematical laws, and knowledge of how they are evolved and of the limitations in their use;
   (b) knowledge of materials, machines and structures.

"2. Thorough understanding of the engineering method and elementary competence in its application. This requires:
   (a) comprehension of the interacting elements in situations which are to be analyzed;
   (b) ability to think straight in the application of fundamental principles to new problems;
   (c) reasonable skill in making approximations, and in choosing the type of approach in the light of the accuracy required and the time available for solution—in sum, a foundation for engineering judgment;
   (d) resourcefulness and originality in devising means to an end;
   (e) understanding of the element of cost in engineering and the ability to deal with this factor just as competently as with technological factors.

"3. Ability to select the significant results of an engineering study and to present them clearly and concisely by verbal and graphic means.

"4. Stimulation of a continuing interest in further professional development."

The objectives of the humanistic-social division are:

"1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.

"2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.

"3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.

"4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.

"5. Development of moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.

"6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study."

Hence, the entire curriculum for the four-year program must be designed to give the student an initial impetus in the several directions indicated. The broader aspects of the petroleum engineering curriculum have been discussed at length by Uren, Stephenson, Vance and others. Current textbooks on petroleum engineering have indicated the course contents of the specialized subjects at certain institutions. However, a recent survey of courses offered by the petroleum engineering schools of the United States shows that some correlation should be made of course contents from school to school, so that petroleum engineering will receive the consideration that has been paid other engineering branches by their respective professional societies.

Fundamentals

In accordance with suggestions from the Engineering Council for Professional Development, more attention is being given currently to the fundamental approach in the undergraduate curriculum, with a minimum emphasis on specialization. Up to 40 per cent or more of the total hours required for graduation are within the specialized department in other fields of

engineering. Although the proportion of hours spent on specialized curricula in petroleum engineering seldom exceeds 20 per cent of the total hours for graduation, serious consideration has been given the fundamental engineering-problem method in teaching even this limited number of subjects in petroleum engineering. All engineering branches function principally in the application of the usual fundamental sciences to their particular specialty. Petroleum engineering is not different from other engineering branches in this respect. Actual training in the sciences is done outside the engineering departments.

In common with other engineering branches, the pertroleum engineering literature has become increasingly mathematical. A good understanding of advanced calculus is necessary before some papers presented before petroleum and technical societies can be digested and applied to ordinary problems. This situation presents the opposite and extreme from the purely "descriptive approach," and requires study of the upper technical limits to which undergraduate requirements should be raised.

A survey conducted by the author several years ago indicated that the majority of operators and engineers consulted believed that completion of the ordinary calculus was sufficient for undergraduate purposes. Advanced mathematical studies, they believed, should be considered only at the graduate level. Such a procedure naturally limits the consideration of undergraduate studies requiring advanced mathematics as prerequisites. However, from the standpoint of usual engineering practice, a surprisingly large proportion of engineering problems require no more mathematical foundation than that offered in the usual four-year college program. It is our belief that the curricula should be so designed that avenues will be left open for continued study in the several allied fields, so that the question of technical difficulties will be solved by the simple expedient of continuing studies into the graduate schools. Two or three years of graduate study or its equivalent is a minimum additional preparation for any student contemplating a career in research, regardless of his engineering branch.

In the long run, an ability to utilize engineering training in terms of the usual engineering concepts, including a liberal sprinkling of practical economics, may prove to be a better leverage for the operating engineer than an intimate acquaintance with mathematics beyond the usual calculus.

Engineering-problem Method

As shown previously, there is nothing new in proposing a "quantitative" or problem approach to specialized courses in petroleum engineering. Most of the schools have adopted in some measure or other the engineering-problem method of instruction. Obviously, it is unreasonable to presume that such courses should be "standardized." Although standardization may be approximated, differences in regional requirements will prevent the adoption of rigid programs. But, a free exchange of ideas through educational committees, adoption of summer schools for teachers in accordance with precedents set by other engineering branches, interchange of instructors with engineers in industry, and other expedients, should enable educators to sift the chaff from the wheat to the betterment of engineering schools and the profession in general.

In order to outline suitable subject matter for the specialized curricula, it is well to inquire: What unique features common to petroleum engineering make it desirable to select this material? Granting that the courses in the other branches of engineering will give the student a satisfactory general background, an attempt is made to answer this question broadly from the composite experience of the author and

various well-known educators and practicing petroleum engineers.

Specialized Courses

The introductory specialized course deals directly with the material the engineer must handle, sell, and be conscious about—petroleum. He is concerned with the origin of petroleum, its composition, classification and description; its physical properties, molecular weight, characterization and derived indices, and the correlation of physical properties with chemical constitution. Attention is placed on the more important group reactions of petroleum, such as oxidation; action of sulphur, light and other radiations; hydrolysis, polymerization, hydrogenation, nitration and alkylation. The usual A.S.T.M. tests a e considered and followed by a summary of evaluation methods.

The next step is more quantitative than the preceding one. Since the conversion of units from one system to another, and the handling of fluid flow, heat flow and other problems in general require some conception of dimensions, the student is introduced to the general principles of dimensional analysis, and analogies, and methods for the calculation of dimensionless numbers. Since a large proportion of the mathematics used in usual operations is empirical, some training is given in curve fitting and the formulation of empirical equations. This is followed by a study of weight and material balances, the ideal behavior of gases, vaporization and condensation. If a service department fails to offer such material, the petroleum engineering student may continue with the study of thermophysics and thermochemistry in his major department. Too much stress cannot be placed upon such fundamental subjects as enthalpy, entropy, specific heats, free energy, heat units, and humidification. This is followed by a detailed study of the compressibility of gases, their fugacity and thermal properties at high pressures, the volumetric and phase behavior of hydrocarbons, and the weight and heat balances of combustion processes.

By this time the student has had some experience in the application of the foregoing to reservoir and production problems. Continued study is made of the application of surface and colloid chemistry, acid treatment, chemical reconditioning and the chemistry of explosives, emulsions, cements and oil well waters.

Process Studies

The sequence of specialized and prerequisite courses thus prepares the student to appreciate more than ever the quantitative approach. Certain processes, which we will term "petroleum processes" for the present, demand more originality and a more precise handling of the usual mathematics on the part of the student. Included in this category are such processes as heat transfer, diffusion, fluid films, gas compression and expansion, distillation, absorption, extraction, stabilization, pipe-line flow of fluids, vertical flow of fluids, flow restriction and control, surface and subsurface pumps and pumping. Throughout these process studies the problems offered for solution will relate to reservoir performance, production of fluids, oil and gas separation, preliminary refining; natural gasoline, distillate, carbon black, oil shale, and processing of synthetic fuel; flow of fluids in pipe lines, desalting, mud circulation, cement circulation, production control, water injection, and measurement of fluids.

Concurrently with the course in "petroleum processes" described previously, the student makes certain laboratory determinations, since the principles involved are basically and uniquely significant to petroleum engineering. He determines the various physical properties of petroleum.

His examinations include: gas analysis, molecular weight, deviation of natural gas, simple distillation, true boiling point distillation, low-temperature fractionation, absorption fractionation, and correlation of the physical properties with the chemical constitution of petroleum.

In the core laboratory he determines porosity by various methods; fluid, water and oil saturation; permeability; salinity. He displays these analyses graphically and makes quantitative determinations with respect to the petroleum reservoir. He also learns to sample and analyze reservoir fluids under natural conditions of temperature and pressure, and to determine pressure volume relationships, saturation pressure, shrinkage, gas-oil ratio and viscosity.

The student's examination of drilling fluids includes various physical properties such as viscosity, density, sand content, hydrogen-ion concentration, particle-size distribution and surface characteristics. He notes the effect of composition and reagents on viscosity, stability, gel strength, carrying capacity, filtration and wall building. The effects of water, temperature, accelerators, bentonitic and inert materials, and time, on the properties of cement in the fluid and final states are investigated experimentally.

Finally, he acquires some first-hand acquaintance with instrumentation and calibration, including pressure and vacuum gauges, subsurface pressure gauges, well-surveying instruments, bottom-hole samplers, dynamometers, indicating and recording thermometers, liquid meters, gas meters (orifice and positive displacement), service regulators, calorimeters, liquid-level indicators, separators, telemeters, and automatic control mechanisms. Although many of these investigations are "terminal points" in themselves, yet, academically, they serve a broader purpose in preparing the student quantitatively for more advanced studies uniquely characteristic of petroleum engineering.

Place of Geology

The petroleum engineer must apply his training in geology to problems in well completions, production practices, reconditioning, and secondary recovery. He must know some of the elements of subsurface correlation methods. Correlating determinations are therefore made from an examination of drill cuttings and cores. Studies in depth measurements, well surveys, and directional drilling techniques; well logs, driller's logs, time logs, sample logs, electrical logs, gamma-ray logs, geochemical logs, peg models, foraminifera, and micropaleontological objects in general, lead to subsurface correlations and the preparation of geological cross sections, sand maps, prediction of coring points, shooting points, plugback points, and a host of other points. Additional studies are made of insoluble residues, heavy mineral residues, and of isopach, isocon, isosalinity, and isogeothermal maps. This program may seem to be over-extended, but experience has shown the practicability of such instruction in the determination, measurement, and correlation of significant horizons in petroleum reservoirs. This is another example of the "quantitative" approach.

Reservoir Performance

The culminating course in the undergraduate curriculum is the senior course in petroleum reservoir performance. Courses in sedimentation, stratigraphy, structural geology and supporting specialized courses have been completed. Beginning with a study of surface forces and capillary behavior, the student next is concerned with the original distribution of fluids in oil reservoirs and mechanisms for displacement of fluids in sands. This is followed by a more detailed consideration of Darcy's law, permeability, and porosity measurements. The student is introduced next to general hydrodynamical equations, going

no further than his basic mathematics will permit. Studies in steady-state flow, both two-dimensional and three-dimensional, include single-phase incompressible systems, single-phase compressible systems, and multiple-phase compressible systems. These lead to such study of the flow of heterogeneous fluids, particularly recent laboratory research, as the undergraduate student's preparation will permit.

The determination of material and volumetric balances for oil fields is one more evidence of the quantitative approach and its practical application. The same importance is attached to the determination of average reservoir pressure and productivity indices. Rates of water influx and field pressure-production relationships lend themselves readily to the problem approach. The student, at this point, is in a position to make an intelligent classification and determination of reservoir control in terms of the prevailing sources of energy present. He applies his theory of dimensions to the prediction of reservoir performance through experimentation with electrolytic models and other analogies. Case problems with respect to reservoir control are drawn freely from such operations as well completion, acidizing, shooting, gravel packing, perforating, reconditioning, well spacing, repressuring, recycling, and water-flooding. Further mathematical studies concerning petroleum-reservoir performance requiring a more extended use of advanced calculus such as partial differential equations, vectors, and Fourier series, are offered in the graduate school only.

Oil-field Equipment

Of equal rank with the previously described study of "petroleum processes" is the course concerned with the design, selection, and performance of oil-field equipment, and representing the application of prerequisites in the chemistry and strength of materials, mechanism and power transmission. The various factors such as stresses and corresponding strains, wear and tear, load and torque ratings, capacities, lubrication, performance, and expected life, are everyday considerations of the future production engineer. He may not design equipment at the plant, but he will be called upon to furnish field data for design purposes. From an operational and semidesign standpoint, however, the student is given specialized instruction in concrete and reinforced concrete; foundations, floors and stanchions; derricks and gin poles; tubular goods; casing strings; tubing strings; unfired pressure vessels; storage tanks, and piling. In his specialized consideration of the general principles of power transmission he considers horsepower and torque calculations and operational data on belting; chain drives; shafting; bearings; reduction gears; variable speed controls; clutches, couplings and collars; hoists and hoisting blocks; wire lines; pumping units; drill pipe; sucker rods; engines and motors. Opportunities for the quantitative or problem approach are obviously manifold in such studies.

Economics

At least one course in the application of economics to petroleum is offered in the specialized curricula which should serve to inspire the student with the world-wide importance of the industry and show unmistakably that very important factors other than quantitative methods will have considerable influence on his future career. Such a course may include:* the geographic distribution of petroleum; oil-land acquisition and control; oil-industry finance; labor; industrial management; taxation; production control; the cost of producing petroleum; petroleum cost accounting; petroleum transportation; international commerce; petroleum statistics; and the conservation of petroleum resources.

* Suggested by outline from Professor L. C. Uren, University of California.

If time permits, a course in the evaluation of oil and gas properties not only demonstrates the problem approach, but should prove to be stimulating to the student in the manifold aspects of the study, embracing on the one hand, broad principles of economics, and on the other hand, scientific methods for the estimation of oil and gas reserves. Evaluation methods are considered from the standpoints of natural-gas public utility properties as well as the usual commercial oil and gas appraisal. Some review of the mathematics of finance will be necessary, which will be followed by a detailed appraisal involving the inventory of physical equipment, the estimation of reserves, and the finished "present worth value." Methods for estimating reserves include the usual graphical analyses, as well as the volumetric and material-balance methods. Since the basic theory involved has been included in specialized courses previously described, there is some difference of opinion as to whether this course should be required or offered as an "elective." The author is inclined to lean toward the second alternative.

Simplification

Thus, the teaching of engineering in general involves many factors including the problem of quantitative approach. Although such personal attributes as personality and cooperative capacity will probably be of more apparent significance in professional advancement, yet that inherent ability to analyze the various elements of the problem and present to management a clearcut conclusion from the evidence, must be the rock upon which the remaining professional qualifications rest. The problems in the classroom should be relatively new. Their solution should be obtained by the application of fundamental principles, and not by substitution in formulas. Deductions may be made from established generalizations of science. On the other hand, observed data may lead to certain conclusions. The important elements of the problem must be studied and a solution selected and applied, observing the usual simplifying assumptions. Problems that are too easy or too difficult will be of little educational value. They should be difficult enough to tax the students' powers of achievement, but not so difficult as to lead to discouragement.

Furthermore, the petroleum engineering student, in particular, should be taught that, contrary to a prevailing tendency in current technical literature, it is not necessarily "smart" or good judgment to camouflage his reports unnecessarily with undue "technical flavor." On the other hand, he should be taught certain principles of intellectual honesty that will admit that all unusually difficult studies and problems should finally be reduced to ordinary language that the business executive can understand. In other words, if double integrations, partial derivatives, and so on must be in the report, assign them to their proper place therein and summarize the results simply in another section for the attention of those who may wish to know whether or not the engineering staff is worth its salt. Truly, he must be taught that the art of making complex things simple is an art indeed for the engineering student to contemplate.

Basis of All Engineering

Not only does a good groundwork in basic subjects appear essential to the undergraduate student, but a continuation of the quantitative approach in the application of these principles provides him with the ability to turn to other branches of engineering, if, following graduation, he should so desire. It is not uncommon today for a graduate in petroleum engineering to study for a fifth year and receive a degree in mechanical or chemical engineering. Such leeways in course structure permit the student to defer his decision until he

becomes of more mature age. He may, thereby, not only have the broad background afforded by the petroleum engineering curricula, but also an additional specialized background of his own choosing.

What of the future of petroleum engineering? Exploratory methods have greatly increased the rate of discovering oil fields. When the flush fields go, secondary methods will be of more importance, but even secondary methods cannot be expected to provide a source of oil indefinitely. However, we do know that substitutes for petroleum will make their appearance in ever increasing quantities as petroleum reserves diminish. The literature is replete with technical discussions concerning the carbonization and hydrogenation of coal; the Fisher-Tropsch synthesis from natural gas, lignite and coal; the retorting of oil shale and tar sands; the processing of fuel from agricultural and other materials. Certainly, another argument for the type of specialized courses suggested is the recognition of the possible extensions of the petroleum engineer's activities into the realm of synthetic fuels. Must we throw up our hands and turn to some other branch of engineering when and if such a change in technique is indicated? Such new operations smack strongly of mining! It seems as though the petroleum engineer, properly trained academically through his basic sciences, the quantitative approach, and the usual "petroleum processes," and well seasoned in industrial experience, should continue with little difficulty in the fuel engineering of tomorrow. In short, the training of today should contemplate every contingency in the professional life of the petroleum engineer of the future!

Summary

In conclusion, the student in petroleum engineering must have sound preparation in basic fundamentals. He must be able to analyze his problems quantitatively and recognize, separately, the various elements involved. He must know what qualities go to make up engineering judgment; that is, skill in reaching the best possible conclusion under the limitations of allotted time and required accuracy. He must appreciate the importance of cost and of practical economics. He must be able to organize his thoughts and to express them clearly through speech and written English. He must be willing and able to adjust his personality to his environment. Finally, he must have a decided interest in continued professional development, and a sound philosophy of social values.

Acknowledgment

Although this paper has been written from the particular viewpoint of the author, yet he wishes to express his appreciation to the members of the committee on education, other educators from the various petroleum engineering schools and the practicing engineers in the petroleum industry for their helpful comments concerning the subject of this paper.

Chapter V. Refining

Review of Refinery Engineering for 1944*

By Walter Miller,† Member A.I.M.E.

Hundred-octane aviation gasoline, toluene for T.N.T. production, high-quality lubricating oils for the needs of aviation and the armed forces, and synthetic chemicals for rubber manufacture again commanded the top priorities of the petroleum refining industry in 1944, the third year of America's active participation in the war. The objective continued to be to produce more and more of these materials—to keep up with increasingly greater requirements.

By the end of the year all of the new installations projected before 1944, with the exception of possibly two or three that will tail over into January or February of 1945, had been completed and put into operation. And with the completion and putting into operation of these various units and the consequent lessening of construction responsibilities and problems, the industry was put into position to concentrate on the new operations and devote much more of its time and effort looking toward maximum output, both as to quantity and quality from the new facilities.

Aviation Gasoline

Making high-octane aviation gasoline continued to be the prime requisite of refining activities during 1944 as it was in the two previous war years, with the sights at the end of the year set to still higher figures than those which had been previously projected.

About July 1 the daily output had been raised to 400,000 bbl., with some few large plant installations still to be completed and put into operation. Indications were that by December production would be up to all requirements, with good inventories. However, although by the end of the year the industry was turning out something over 500,000 bbl. a day, the estimated requirements of the armed services had been raised by a considerable figure, owing to the greatly increased aerial activities both in the European and Far Eastern combat areas. By the end of the year, therefore, the picture had changed, with the prospect for a much longer continuation of the European war, so that even with the completion and putting into operation in the United States by January 1945 of the last two or three 100-octane units authorized prior to 1944, it was evident it would be necessary to make still greater efforts to increase output of existing facilities to keep safely ahead of the game.

Efforts of the industry and the Petroleum Administration for War as well as the Technical Advisory Committee and other research and development groups are concentrated therefore on methods and means of further augmenting the production of all existing refinery facilities engaged in making 100-octane aviation gasoline and components entering into it. The goal will be reached.

* Reprinted from *Mining and Metallurgy*, February, 1945.

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One of the means to increase coming production will undoubtedly be the more extensive use of stronger synthetic catalysts in many of the catalytic cracking units.

Announcement has been made of priorities having been granted for two additional large-sized 100-octane plants, one of which will possibly be completed in 1945 and the other early in 1946, neither in time, however, to help materially during the coming year.

Another possibility that has been worked on extensively during the year is the hydrocarbon compound known as triptane —2-2-3 trimethylbutane. This has an octane blending value considerably in excess of toluene, and a gasoline made using triptane and tetraethyl lead is one of the most powerful combinations so far developed. A 12-cylinder Allison engine, with rated take-off power of 1500 hp. with 100-octane gasoline, is said to have developed over 2500 hp. with triptane and lead tetraethyl blends. Triptane was practically a laboratory curiosity up to a short time ago. A pilot plant has been developed capable of producing 10 bbl. a day, which has made possible some fairly extensive testing in airplanes and other war equipment. Details of this development are secret, of course, and no information is available as to whether and when large-scale plants can or will be installed.

Plans have been announced for the manufacture of a new "superfuel" of far greater power, developed by technologists of our refining industry, designed primarily for use of planes taking off from the decks of aircraft carriers, the flat-tops of our Navy, and in the B-29 bombers and the like. Only about half as much of this type of fuel can be made from a barrel of crude as the present regular 100-octane material, but no extensive changes in existing plants are required to produce it. Many refineries are in position to start making this fuel quickly, but extensive manufacture will be delayed until the production of the present 100-octane material reaches an excess as the making of the superfuel entails a reduction in the ratio of about two barrels of the present fuel for every barrel of the new fuel produced.

Toluene For T.N.T.

At the end of 1943, refiners manufacturing toluene were in the position of making considerably in excess of the quantity needed for the T.N.T. requirements of the armed services, and the 100-octane gasoline program was helped by having the surplus diverted to it as a blending component for which it is highly suitable and valuable. Despite some increase in the production rate of some of the plants, the excess is being reduced rapidly. The same factors that increased the need of aviation gasoline—namely, greater aerial and bombing activities in the war areas—are responsible for higher T.N.T. requirements, and the surplus of toluene available for 100-octane gasoline blending operations is therefore being lessened by something of the order of 5000 bbl. a day, increasing to that extent the burden on manufacturers of aviation gasoline.

Efforts are also continuing to increase the output of existing facilities by research and development activities. Toluene is one of the petroleum materials that is critically important to the war program in more than one use.

Toluene is being produced by petroleum refiners in this war at rates ten to fifteen times as great as the quantity available in World War I, at which time the coal-tar industry was practically the only source of supply.

High-quality Lubricating Oil

Practically all the large and small projects authorized prior to 1944 have been completed and put into operation.

A number of minor additions to existing plants were authorized, including alterations to remove bottlenecks and increase output.

On the whole, the available supply exceeded the demands of the armed services, and there is no apprehension of any impending shortage. Global inventories of the armed forces have been largely supplied, of course, and current production has taken care of continuing needs. Should an unexpectedly larger consumption develop, it might be necessary to take part of it from lubricants of suitable quality now being used for civilian purposes, but such a situation is not expected to develop.

A large number of new plants have been projected on paper and submitted to Washington for postwar development and for quality improvement, some of which may be authorized before the end of the war, presumably depending largely upon the availability of materials and labor necessary for their construction. Three projects in easy manpower localities are under immediate consideration in Washington, but none of them is authorized as yet. The high-quality lubricating-oil situation is well in hand.

Synthetic Rubber from Petroleum

The petroleum refiners' contribution to the synthetic rubber program apparently is being fulfilled as projected. No additional butadiene plants are planned; previously projected units are all completed and in operation. Most of them are capable of producing at better than designed rates, and all as a group are turning out raw material for synthetic rubber faster than the tire manufacturing plants can use it. On Rubber Director Bradley Dewey's recommendation, his division of the War Production Board was dissolved the latter part of the year, and the continuing of the rubber program taken over by the War Production Board as part of one of its other regular divisions. Unfortunately for civilians, it will still be a long time before tires will be freely available. Estimates have been made that restrictions will continue, in spite of ample raw material for synthetic rubber, at least throughout the year. Part of the difficulty responsible for this situation is, of course, the vastly increased requirements of the armed services beyond previous estimates, due to the extension of the European war and the increase in land activities in the Asiatic area. It may be well into 1946 before the average civilian will be able to get tires except under the most justifiable conditions.

A great lack of finished tires continues, because the tire plants are suffering from a manpower shortage and excessive absenteeism. However, at least two new tire-manufacturing plants have recently been completed, one in Oklahoma and one in Texas, which will help that situation somewhat, and the problem of the manpower shortage has been checked to the War Manpower Commission. The fact remains that the refining industry has made and is making good on its assignment in the synthetic rubber program.

The situation is not yet clear as to the postwar cost of producing synthetic rubbers and the competitive position of synthetic with natural rubber in the postwar era, but many indications are that the synthetic costs will be at satisfactorily low levels. Reliable figures should be available during the coming year, as the plants build up records on continuing operations.

Research and Development

As in previous war years, research and development efforts continued cooperatively under the joint auspices of the Petroleum Industry for War Council and Petroleum Administration for War, largely through the activity channels of the Aviation Gasoline Advisory Committee, the Toluene Technical Com-

mittee, and the Technical Advisory Committee. The number of petroleum technologists actively engaged in this cooperative research and development was considerably increased by enlargement of membership of the working subcommittees.

A definite broadening of process development work was seen as the new plants went on the production line, necessary because of the incompletely developed new methods. The efforts of many of those who had been engrossed in the construction and preparation of the new units became available for problems concerned with the perfecting of operative technique, improving the continuity of operations, the further study of corrosion and erosion difficulties, and the establishing, for large-scale operations, of the most practical and efficient conditions.

Much is being accomplished by having regular meetings at about 60-day intervals in the various P.A.W. refining districts of the operating and technological staffs of the plants engaged in 100-octane and components production. A forum is thus provided for a free and full discussion of all the questions affecting production rate, quality, and in general continued improvement in the utilization of these important manufacturing facilities—a pooling of experience and knowledge gained by those men in the line of immediate direction and supervision, men actually on the ground about the facilities and in intimate contact with all operating steps and problems.

A development worth noting, although not near enough to be applicable to war production, is the growing interest in possible applications of the Fischer-Tropsch process, or modifications thereof, to some of our large gas reserves. This is one of the sources that are looked to for augmenting future crude-oil supply as and when the oil wells fail to completely fill the demand. Three or four pilot plants, the largest with a capacity of between 15 and 20 bbl. per day of liquid oil output, are in operation developing information as to engineering data for large plants, yields, costs, and commercial feasibility of such operations. There is even some thought that plants may be designed to be economical under present-day or immediate postwar conditions. Quite possibly all the research and development activities known to be under way now may lead to definite and encouraging conclusions during the coming year.

Research and broader operating experience are adding much to catalytic cracking and other catalytic operations such as isomerization and alkylation, information and developments utilized in operations as available, but the veil of secrecy, except for those in position to make practical applications in the war effort, still holds.

Crude and General Products

Charge of crude oil to stills increased to unprecedently high figures.

Compared with an average of about 4,200,000 bbl. per day in December 1943, we have a figure close to 4,600,000 bbl. average in December 1944. The 1943 year's average of approximately 3,910,000 bbl. is exceeded, as will be shown when final figures are available, by about 600,000 bbl. per day for a 1944 average of approximately 4,525,000 bbl. per day. Doing this cut into the country's over-all crude-oil stocks by about 20,000,000 barrels.

Motor-gasoline rationing continues. Transportation difficulties decreased to some extent but increased diversion of petroleum products to war purposes prevented any easing up of gasoline rationing. Daily military uses of gasoline have increased by 200,000+ bbl., to a total of more than 800,000 bbl. per day, so it has taken the increased refinery runs and the somewhat greater transportation capacities to avoid the necessity of

still further reducing gasoline for the public. The situation is not likely to change until at least the European war is ended.

Tetraethyl lead for gasoline again developed into a problem. The great quantitative increase in 100-octane gasoline with its 4.6 c.c. per gallon consumption (with much of it at 6 c.c. per gallon for several months), as well as increased quantities of other war gasolines, made it necessary to restrict the use of lead materially in civilian gasoline, thereby reducing the quantity of high-octane premium-grade gasoline available to the public. Production of premium gasoline was quantitatively cut in June to 50 per cent of the base period (October 1943, to March 1944) and again to 25 per cent of the same base period on Oct. 1. An improvement in the supply permitted raising production of premium gasoline to 37.5 per cent effective the last week in December.

During the year there were a few scares on kerosine and the lighter fuel oils used for household heating, but the situations were worked out to the best possible degree by the control efforts of P.A.W. with the cooperation of the industry. The expedient of shipping kerosine in drums in railroad boxcars from the Gulf Coast refineries to the New England States was again resorted to at the end of the year. Juggling back and forth between light and heavy gas oils, between kerosine and domestic burner oils by P.A.W. and the industry will continue as needs arise.

The industrial heavy fuel oil situation is, however, considerably changed. With the high crude runs there was a natural increase of heavy fuel oil, which more than overbalanced any decrease effected by catalytic cracking operations, and so at the end of the year some 4,000,000 bbl. more were on hand than at the first of 1944, and the outlook is for further inventory additions.

In general, national inventories of petroleum products are in somewhat better position than a year ago, but merely enough to reduce some of the apprehension previously felt. This heavy fuel oil situation is the only comfortable product inventory picture.

In the industry and in P.A.W. there is every confidence that we will continue to meet all demands and handle exigencies and emergencies as they arise.

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(NOTE: In this index the names of authors of papers and discussions and of men referred to are printed in SMALL CAPITALS, and the titles of papers in *italics*.)